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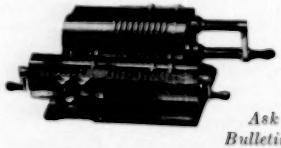

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THE QUARTERLY REVIEW *of* BIOLOGY

PHOTOPERIODISM IN PLANTS

By A. C. LEOPOLD

Purdue University, Lafayette, Indiana

LENGTH of day has a profound effect on many developmental functions of plants. The existence of this extremely subtle factor in the environment was first recognized by Klebs in 1918. The extent of biological impact of day length as a factor in plant development was first demonstrated by Garner and Allard in 1920. They introduced the term photoperiodism to cover the developmental responses of plants to day-length. Since then, many workers have helped to clarify the principles governing the photoperiod responses, but the underlying mechanism or physiological dynamics are yet to be discovered.

The biological literature dealing with photoperiodism in plants has been extensively reviewed in three recent books (Whyte, 1946; Murneek et al., 1948; Wigglesworth et al., 1948). Consequently there is no need for a detailed review at this time. However, because researches published even in the last few years have considerably altered the understanding of photoperiod phenomena, it is believed that a brief review of the present status of the field may be constructive. For the sake of simplicity, the discussion in this review will be limited to the photoperiodic control of flower initiation, except where specific points of interest concerning the other photoperiodic phenomena are considered noteworthy.

The study of flower initiation has been a search for the cause of the dramatic change which takes place when the meristem of a vegetative plant, capable only of laying down leaf primordia after leaf primordia, suddenly is given the impetus to start forming flower primordia instead. This remarkable change in the development of a plant may be brought about by exposing the plant to only a slight change in day-length. In some plants an inductive day-length need be given only once to bring about reproductive activity. Other species require its repetition for several diurnal cycles.

Before attempting to discuss the physiological aspects of photoperiodism, we will briefly review the empirical facts upon which the study of photoperiodism rests.

THE BASIS OF PHOTOPERIODISM

The nature of the stimulus and the response

In the thirty years since the discovery of photoperiodism, many empirical facts relating to the basic nature of photoperiodism have been found.

Firstly, the perception of photoperiodism occurs primarily in leaves (Cajlachjan, 1936). During expansion leaves are quite insensitive, but as soon as full size is reached they show maximum sensitivity to photoperiods. As the leaves age beyond this stage, a gradual decline in relative sensitivity sets in (Borthwick and Parker, 1940). It is interesting to find that in a few isolated cases flowering has been altered by photoperiodic treatment of rhizomes and stems (Dostal, 1944; Harder and Westphal, 1944). Preliminary experiments in this laboratory suggest that with prolonged photoperiodic treatment, green stems of cocklebur can

receive the flower inducing stimulus. Photoperiodic influences on growth and dormancy are not felt only by leaves, but by buds and stems as well (Kramer, 1936). Nevertheless, the leaves are certainly the principal receptors of the flowering stimulus.

Secondly, and obviously, the response is initiated in the bud, and consequently it can be deduced at once that the flowering stimulus must move from its place of origin in the leaves to its place of expression in the buds. This led the early workers to the hypothesis that the stimulus was of hormonal nature (Cajlachjan, 1936). The proposed flowering hormone has not been found as yet, but

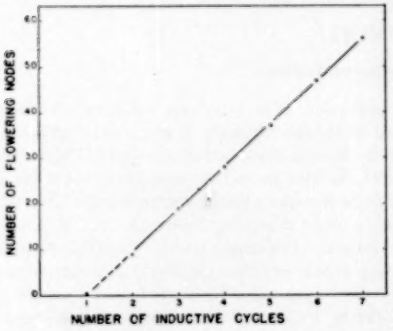

FIG. 1. AN EXAMPLE OF THE QUANTITATIVE PROPERTY OF PHOTOPERIODIC INDUCTION: FLOWER INITIATION OF SOYBEAN AS A FUNCTION OF NUMBER OF INDUCTIVE CYCLES GIVEN

Data of Hamner, 1940.

the stimulus has been found to move principally in the phloem (ibid). Other living cells are capable of transmitting the stimulus, but dead cells—killed or naturally dead as in the case of mature xylem cells—cannot transmit it. Other characteristics of the movement of the photoperiodic stimulus will be discussed later.

Thirdly, the response itself is both qualitative and quantitative. As the flowering stimulus reaches the growing points of the plant, a qualitative changeover from production of vegetative primordia to flower primordia takes place, and the quantity of flower primordia formed is proportional to the intensity of the stimulus received. The linear relationship between the number of inducing photoperiods and the number of flowers formed in soybean plants is demonstrated by the data in Fig. 1. Of course there are limits to this linear relationship, and with excessive photoperiodic induction the increase in flowering diminishes and finally ceases when all buds have become completely reproductive, no undifferentiated primordia being available for further flower formation.

Photoperiod classes

Plants in general can be grouped into three different classes according to their photoperiod requirements for flower initiation: short-day plants, long-day plants, and indeterminate plants (Garner and Allard, 1920).

Short-day plants generally require light periods of less than 12 to 15 hours in a 24-hour cycle to induce flowering. The distinctive feature of short-day plants is that a long dark period is essential for flower initiation. This requirement for long dark periods is clearly shown by studies using cycles of less than 24 hours. Such studies with short-day cocklebur have shown that as little as one-half hour of strong light may suffice for an inducing day if followed by a long dark period of nine hours or more (Hamner, 1940). Different species will have different specific requirements of day and night length, of course. If long nights are given but are interrupted by light, even briefly, the inductive effect of the cycle is entirely lost (Hamner and Bonner, 1938).

Long-day plants generally require light periods of 12 hours duration or more to induce flowering. The distinctive feature of long-day plants is that long night periods entirely prevent flower initiation. If long nights are given but interrupted by light, even briefly, the inhibitive effect of the night is lost and the plants can initiate flowers.

Indeterminate plants are those in which flowering is independent of photoperiodism. Initiation of flowers in these species is not determined by the day-length or the night-length.

Some examples of each of these three response types are presented in Table 1. It should be pointed out that some plants have an absolute requirement for a given type of photoperiod, while others are only promoted or hastened in flowering by favorable photoperiods. In so far as possible, detailed work on the nature of photoperiodism is carried out using species which have an absolute requirement for photoperiods. This accounts for the great preponderance of research being done on only a few species.

TABLE 1

Examples of species of plants sensitive to photoperiods for flower initiation

SPECIES		REFERENCE
LONG DAY PLANTS		
Plants specifically requiring long days:		
Anethum graveolens, L.	dill	Hamner & Naylor, 1939
Baeria chrysostoma, Fish & Meyer		Sivori & Went, 1944
Beta vulgaris, L.	sugar beet	Stout, 1945
Hordeum vulgare, L.	Wintex barley	Borthwick et al, 1942
Hyoscyamus niger, L.	black henbane	Melchers, 1936
Papaver somniferum, L.	opium poppy	Khlebnikova, 1941
Plantago lanceolata, L.	plantain	Snyder, 1948
Rudbeckia bicolor, Nutt.	coneflower	Murneek, 1940
Silphium trifoliatum, L.	rosinweed	Allard & Garner, 1940
Spinacea oleracea, L.	spinach	Garner & Allard, 1920
Plants promoted by long days:		
Allium cepa, L.	onion (line "74")	Scully et al, 1945
Centaurea cyanus, L.	cornflower	Funke, 1948
Lactuca sativa, L.	lettuce	Bremer, 1931
Linum usitatissimum, L.	flax	Nuttonson, 1948
Parthenium argentatum, Gray	guayule	Whitehead & Mitchell, 1943
Phleum pratense, L.	timothy	Hamner & Naylor, 1939
Poa pratensis, L.	bluegrass	Peterson & Loomis, 1949
Ricinus communis, L.	castor bean	Scully & Domingo, 1947
Solanum tuberosum, L.	McCormick potato	Werner, 1941
Triticum aestivum, L.	Marquis wheat	Garner & Allard, 1923
SHORT DAY PLANTS		
Plants specifically requiring short days:		
Amaranthus caudatus, L.	milme	Fuller, 1949
Ambrosia artemisiifolia, L.	ragweed	Garner & Allard, 1920
Chrysanthemum morifolium, Ram.		Cajlachjan, 1936
Euchlaena mexicana, Schrad.	Chalco teosinte	Emerson, 1924
Euphorbia pulcherrima, Willd.	poinsettia	Garner & Allard, 1923
Glycine max, Merr.	Biloxi soybean	Garner & Allard, 1920
Kalanchoe blossfeldiana, Poellnitz.		Harder & v. Witsch, 1940
Nicotiana tabacum, L.	Maryland Mammuth tobacco	Garner & Allard, 1920
Perilla frutescens var. *nankinensis*, Bailey		Cajlachjan, 1936
Xanthium pennsylvanicum, Wallr.	cocklebur	Hamner & Bonner, 1938
Plants promoted by short days:		
Ananas comosus, Merr.	pineapple	van Overbeek, 1946
Coffea arabica, L.	coffee	Franco, 1941
Cosmos bipinnatus, Cav.		Garner & Allard, 1923
Fragaria chiloensis, Duchesne	strawberry	Murneek, 1948
Glycine max, Merr.	Mandarin soybean	Garner & Allard, 1920
Gossypium hirsutum, L.	cotton	Sen, 1944
Oryza sativa, L.	rice	Sircar, 1948
Primula malacoides, Franch.	primrose	Post, 1936
Saccharum officinarum, L.	sugar cane	Yusuff & Dutt, 1945
Salvia splendens, Ker.	scarlet sage	Withrow & Biebel, 1936

There is a tendency for photoperiod requirements to follow taxonomic lines. For example, most Cruciferae are long-day plants, most tobaccos are indeterminate, and most goldenrods are short-day plants. However, different requirements sometimes occur within the same species. Thus, there are short-day and indeterminate soybeans, races of side-oats gramma grass (*Bouteloua curtipendula*) with short-day, long-day and indeterminate tendencies (Olmstead, 1943), and species of tobacco which are short-day plants and one species which is a long-day plant (Allard, 1943).

The recognition of these three classes of photoperiod responses has been criticized on the basis that several factors such as temperature, light intensity, and age of the plant can modify the threshold photoperiod requirements. However, the fact that the photoperiod sensitivity is subject to environmental modification should not invalidate the classification. Neither does the ability of a species to be modified by its environment invalidate its taxonomy. Another criticism has been that a plant may show different photoperiod preferences for different developmental stages (e.g. flower initiation, fruit development, dormancy, etc.). It should be remembered, however, that this classification as originally set up by Garner and Allard was intended to classify only flowering responses to photoperiodism.

It may be mentioned here that the existence of a genetic basis for the photoperiodic response has been established in several instances. In some cases the photoperiodic requirement of a plant has been found to depend on a single allelic pair (Bremer, 1931; Lang, 1948), whereas in other cases as many as nine allelic pairs have been found to be involved (Goodwin, 1944).

METAMORPHOSIS TO THE FLOWERING CONDITION

Our knowledge as to the nature of the photoperiodic stimulus can only be deduced from information on what factors are involved in bringing a plant into the flowering condition, and what changes can be observed in the plant as floral development sets in.

Looking first at the primary factors which may play a role in the photoperiodic response, these will be discussed under the headings of light and dark.

The role of light

Although short-day plants require long nights for flowering, prolonged darkness alone will not suffice for flower initiation in green plants. A light- or photo-period has been shown to be essential before the long dark period for the latter to be effective (Hamner, 1940). It is clear, then, that light periods play an integral part in photoperiodic induction of flowering. It is curious, however, that some plants with large supplies of food materials in seeds or tubers are capable of initiating flower development in total darkness and under conditions of complete etiolation (pea, potato, corn cucumber) (Leopold, 1949; Lang, unp.). Indeed some saprophytes such as Indian-pipe, which grows underground, never do experience light until their well developed flowers emerge from the forest floor.

Generally speaking, however, light is clearly essential for photoperiod processes. Cocklebur requires a minimum of 30 minutes of light at 100 foot-candles to constitute a light period. This minimum for a short day varies inversely with light intensity (Hamner, 1940). Other short-day plants show the same general behavior.

If the light period is interrupted by a short period of darkness, its effectiveness is not seriously altered. However, if the interruption is as great as 90 minutes, a long day is no longer effective as such (Withrow and Withrow, 1944).

Since the requirement for light is so manifest, the question arises as to the nature of the reactions utilizing the light, and the identity of the pigments which must necessarily be activating the reactions. Light appears to have at least a dual role in photoperiodism:

1. *Photoactivation.* As has been stated above, light is required before the dark period, and this light must be of relatively high intensity. Cocklebur and soybean require a minimum of 100 foot-candles. Stronger light intensities are more effective. This quantitative relationship between light intensity and photoperiod sensitivity for the short-day plant soybean is shown in Fig. 2.

The requirement for relatively high-intensity light for the light period suggests at once that photosynthesis is the photo-reaction involved. Several lines of evidences strongly support such an hypothesis: carbon dioxide is essential for the utilization of the light, and sugars or organic acids can be substituted for the light period under some circumstances (Parker and Borthwick, 1940; Bonner, 1950).

There is some confusion in the literature as to the possible role of photosynthesis in photoperiodism. The main source of doubt as to its possible

role stems from the fact that very weak light can alter the effectiveness of a given day-length. It is now clear, however, that light of an intensity high enough for photosynthesis (100 f.c. or above, cf. Fig. 2) is essential for any inductive photoperiod. The effect of weak light has recently been clearly shown to affect not the day period but rather the night or dark period (Hamner, 1940). This second separate action of light in photoperiodism will be discussed in detail in the next section.

2. *Photoinactivation.* Long nights are prerequisite to flower initiation in short-day plants and prohibit flowering in long-day plants. Interruption of long nights by even minute intensities of light can completely erase the photoperiodic effect of the night.

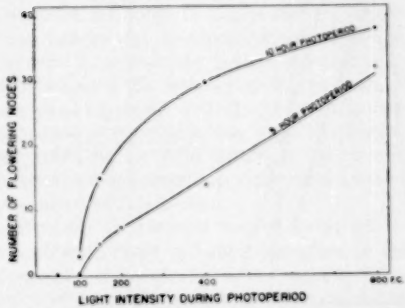

FIG. 2. AN EXAMPLE OF THE ROLE OF INTENSITY OF LIGHT IN THE PHOTOACTIVATION REACTION: FLOWER INITIATION OF SOYBEAN AS ALTERED BY LIGHT INTENSITY DURING THE PHOTOPERIOD
Data of Hamner, 1940.

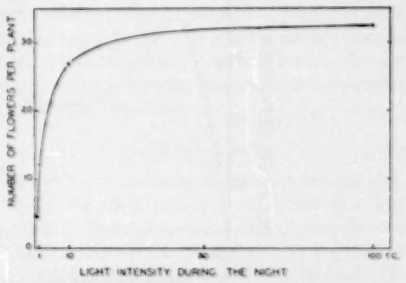

FIG. 3. AN EXAMPLE OF THE ROLE OF INTENSITY OF LIGHT IN THE PHOTOINACTIVATION REACTION: FLOWERING OF PANSY, A LONG-DAY PLANT, AS ALTERED BY LIGHT INTENSITY DURING LONG "NIGHTS"
Data of Withrow and Benedict, 1936.

This disruption of the night reaction can be considered to be a photoinactivation of some light-sensitive step or light-sensitive compound. In contrast to the photoactivating role of light, the photoinactivation is saturated by very low intensities—reportedly as low as ten foot-candles of light. Increasing the intensity above that amount does not proportionately increase the effect, as shown in Fig. 3 (Withrow and Benedict, 1936). This situation contrasts strongly with the intensities utilized in the light period (cf. Figs. 2 and 3). Temperature has been found to have no effect on the light interruption, hence it is a true photoreaction (Harder, Walrabe, and Quantz, 1944).

By experimental use of light of various wavelengths, the workers at Beltsville, Maryland, have determined the sensitivity of the photoinactivation reaction to each part of the spectrum. They have found that red light (620–640 mμ) is most efficient in this reaction, and have plotted the energy levels required over the visible spectrum. From their energy curves (Parker, Hendricks, and Borthwick, 1950), the relative efficiency of various wavelengths have been calculated and plotted in Fig. 4. The action spectra for the photo-inactivation reaction in long-day barley (A), and short-day soybean (B) and cocklebur (C) are shown. The action spectrum for long-day henbane is essentially the same as that of barley over the range measurable (560–730 mμ).

Examination of the action spectra plotted as relative efficiencies brings out several interesting points. First, the shape of the action spectra in the red region is strikingly similar to that for photosynthesis (Fig. 4 D). However, the complete disparity between the two curves in the blue region makes any intimate relationship between the photoinactivation reaction and chlorophyll seem improbable. Furthermore, the overall shape of the action spectrum is strongly suggestive of that for leaf enlargment in etiolated peas (Fig. 4 F), and is roughly comparable to that for the promotion of leaf enlargement in etiolated oats (Fig. 4, E). Also, the shape of the action spectrum is suggestive of the absorption spectra of two known plant pigments: protochlorophyll and phycocyanin (Fig. 4, G, H).

These observations lead to the following inferences concerning the still undiscovered pigment involved in the photoinactivation reaction of photoperiodism. (1) The disparity between the action spectra for photoinactivation and photo-

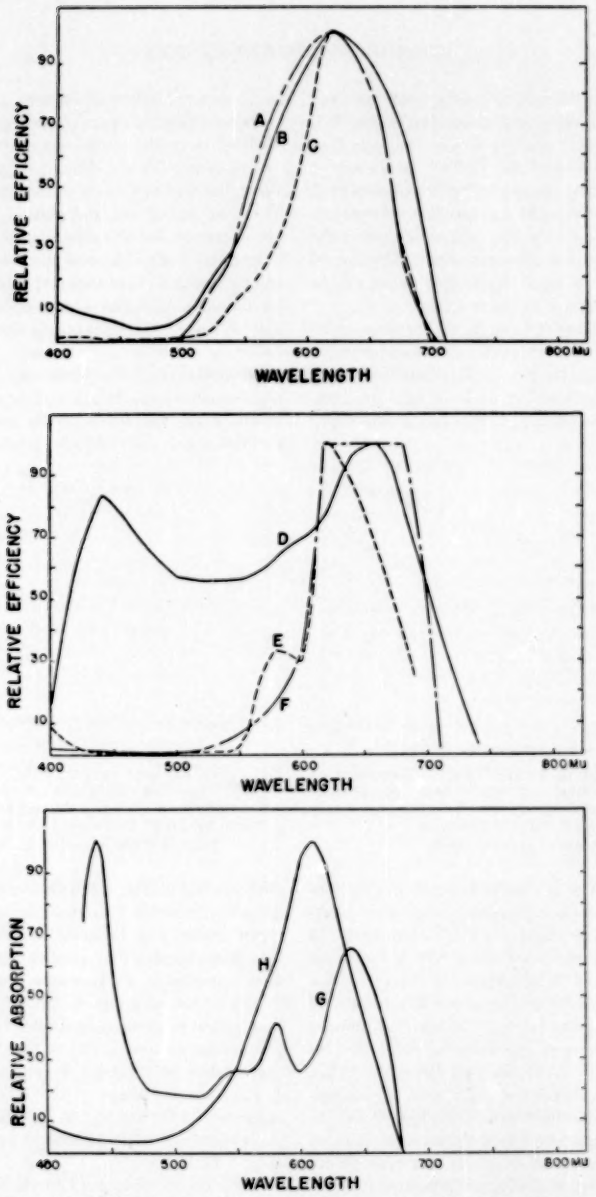

FIG. 4. Top: ACTION SPECTRA FOR PHOTOINACTIVATION OF LONG NIGHTS IN PHOTOPERIODISM
A, long-day barley; B, short-day soybean; C, short-day cocklebur. Calculated from Parker et al., 1950.

Middle: D, ACTION SPECTRA FOR PHOTOSYNTHESIS; E, INHIBITION OF ELONGATION OF THE FIRST INTERNODE OF OAT SEEDLINGS; AND F, LEAF ENLARGEMENT OF ETIOLATED PEA SEEDLINGS
Data of Hoover, 1938; Goodwin & Owens, 1951; and Parker et al., 1949, respectively.

Bottom: ABSORPTION SPECTRA FOR PLANT PIGMENTS
G, protochlorophyll; H, phycocyanin. From Parker et al., 1950.

synthesis suggests that chlorophyll, the most abundant leaf pigment, is not directly involved. (3) The similarity of the action spectrum to that of two other light responses of etiolated seedlings suggests the possibility that the pigment involved in the photoinactivation may participate in other light responses, and may be common in etiolated as well as in green plants. The possibility immediately suggests itself that the responsible pigment may be formed in darkness and may have evaded detection by being light unstable. However, efforts in this laboratory to separate the pigment in darkness have as yet been unsuccessful. (3) The similarity of the action spectrum to the absorption spectra of the plant pigments protochlorophyll and phycocyanin have lead Parker, Hendricks, and Borthwick (1950) to suggest that the responsible pigment may be a porphyrin compound of the protochlorophyll type (perhaps screened in its effectiveness in the blue region by the common carotenoid pigments), or an open-chain tetrapyrole compound of the phycocyanin type. Needless to say, establishment of the identity of the pigment involved will be a great step in the clarification of the photoperiod mechanism.

Whatever the pigment involved in the action, the ultimate result of light interruption is the destruction of the effect of a long night by light. By brief interruptions of long nights, short-day plants can be kept vegetative, (cf. Fig. 4, B, C, soybean and cocklebur) and long-day plants can be induced to flower under short-days (cf. Fig. 4, A, henbane, barley).

As to the actual amount of light energy required for night interruption the careful measurements by Borthwick, Hendricks, and Parker (1948) have shown that the minimum energies required range from 25 to 150 kilocalories per square centimeter of leaf area, when light of greatest efficiency is used (620–640 mμ). When unfiltered light has been used, the dark period has been successfully interrupted by as little as 100 f.c. for 1 minute, or 150 f.c. for ½ minute (Hamner and Bonner, 1938). Again, as little as 0.1 f.c. for an estimated 9 hours has been found to be effective (Withrow and Benedict, 1936). These three figures for unfiltered light all involved very nearly the same quantities of light energy as the amount required in the experiments of the Beltsville group using approximately monochromatic light.

It can be clearly seen that the amount of light energy needed for interruption of long nights is very low indeed. The lowest intensity capable of producing an effect, 0.1 f.c., is approximately 10 times the intensity of moonlight on clear nights, and one ten-thousandth the intensity of normal sunlight (Curtis and Clark, 1950). The small amount of light energy required to interrupt a long night is certainly remarkable. It becomes even more remarkable when one considers that these small quantities of light are utilized by a pigment system so dilute or so transient that it has entirely escaped detection—or at least recognition.

Incidentally, a striking parallelism to the photoinactivation reaction in plants has been found in animals. Animals which require long days for sexual activity will become reproductive under short days if the nights are briefly interrupted by light (Jenner, 1950). Furthermore, from the information available on the relative effectiveness of different colors of light, it appears that red is most effective for destroying the effect of long nights (Benoit and Ott, 1944).

The role of dark

From the information about the photoinactivation of the dark period, it is patent that long periods of darkness are essential for photoperiodic induction of short-day plants, and are prohibitory of induction of long-day plants. The similarities in light sensitivities of the dark reaction in short- and in long-day plants strongly suggests that the same dark reaction may take place in both types. If the dark reaction results in the accumulation of a specific substance involved in flowering, we may infer that this same substance may both induce flowering in short-day plants, and prevent flowering in long-day plants.

It may be well to repeat here that the light period, discussed under "photoactivation" above, must precede the long dark period. Hence it is evident that some substance or condition resulting from the light period is used in, or is essential to the dark reaction. Extension of the duration of, the dark period (twelve hours in the case of soybean) does not quantitatively increase the inductive effect. Instead, before any further additive effect of the dark reaction can be obtained, the light period must be repeated (Hamner, 1940).

The requirement for periodic renewal of the light and then the dark periods is the basis for the photoperiod behavior. Plants sensitive to photoperiods apparently require an absolute

amount of light or light period followed by an absolute amount of uninterrupted dark for one inductive cycle. While ratios of light to dark have been investigated by many workers, they have led to little new information. Absolute minimum amounts of light and dark are involved and not ratios of one to the other. The effect of one pair of diurnal periods is added to by each repetition of the cycle.

While light and dark are the known principal factors involved in photoperiodism, many other modifying factors have been found. These may be divided roughly into five groups: those involving temperature, inorganic nutrition, auxins, metabolites, and growth.

Role of temperature

The factor of temperature, as one might expect, has a potent influence on photoperiodism. Each species seems to have its own temperature range for optimal flowering response, and there seems to be no overall relationship between type of temperature requirement and photoperiod class. For example, out of eleven short-day species chosen at random as being influenced by temperature, seven are promoted in flowering by high temperature, the other four are promoted by low temperatures. Of sixteen long-day species similarly chosen at random, four promoted by high temperatures and the other twelve by low temperatures. There is no strong temperature preference characteristic of plants in any one photoperiod class, although low-temperature preferences are more common among long-day species.

While the temperature effects on photoperiod responses do not follow any set pattern, still they can help to clarify a few characteristics of photoperiodism. For example, it seems very clear that temperature requirements, or at least optimal temperature ranges, can be entirely different for the light and for the dark period. In short-day soybean the dark reaction is very sensitive to low temperatures, and is inhibited by leaf temperatures below 70°F. Indeed, lowering night temperatures to 45°F. can entirely prevent the inductive effect of short photoperiods (Parker and Borthwick, 1943). The light reaction does not show the same sensitivity. On the other hand, poinsettia, another short-day species, requires cool night temperatures and is greatly delayed in flowering when otherwise inducing nights are kept at high temperatures (75°F.) (Roberts, 1943). Further examples of differences in temperature requirements between species and between light and dark periods need not be catalogued here, but suffice it to say that temperatures can markedly alter photoperiod responses, and that temperature requirements during the light period may be quite different from requirements during the dark period.

Some plants with a photoperiodic requirement for flowering can be modified in that requirement, or in some cases the photoperiods can be entirely substituted for, by a temperature change. For example, henbane—a long-day plant—at 22°C. requires a ten-hour minimum day-length for flower initiation, but this requirement can be reduced to 8 hours or increased to almost a 12 hours minimum day-length by lowering or raising the temperature. This relationship between minimum day-length and temperature for henbane is shown in Fig. 5. Again, the long-day requirement of *Rudbeckia bicolor* can be entirely substituted for by high temperatures. Indeed, the species acts as an indeterminate plant if it is subjected to high temperatures (Murneek, 1940).

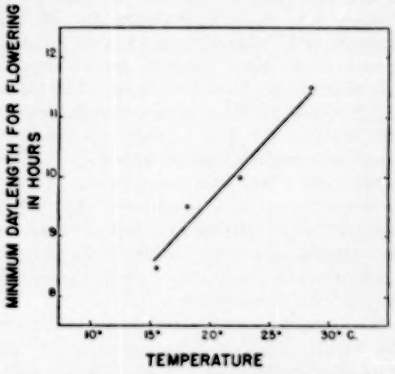

FIG. 5. TEMPERATURE AS A FACTOR MODIFYING THE PHOTOPERIOD REQUIREMENTS FOR FLOWERING OF HENBANE

Data of Lang and Melchers, 1943.

It should be mentioned that there are some plants with specific temperature requirements for flowering which are quite independent of the photoperiod response. Some plants with no photoperiod requirement need a short exposure to a given temperature condition before they are capable of becoming reproductive (e.g., celery) (Thompson, 1933). Others which are photoperiod sensitive

must have a given temperature experience plus a photoperiod experience before floral induction is achieved (e.g., sugar beet) (Owen et al., 1940).

Studies of temperature effects on photoperiodism have yielded constructive information on translocation of the flowering stimulus. It is known that temperatures close to freezing can stop translocation of carbohydrates in plants. The same degree of temperature sensitivity is exhibited by the photoperiod stimulus in moving through the petiole and stem. Cooling either of these structures has been found to retard movement of the flowering stimulus. Cooling the petiole of an induced leaf can prevent the movement of the stimulus from that leaf to the buds (Borthwick and Parker, 1949). Cooling the stem of a weakly induced branch can localize the stimulus in the distal part and result in flower formation where normally the stimulus would be too dilute for expression (Roberts and Struckmeyer, 1938).

Role of inorganic nutrients

Before photoperiodism was discovered, some workers had found that changes in quantities of nitrogen available to plants could strongly alter flowering and fruiting. These early observations were made before critical standards for the study of flower initiation had been established. In more recent years, however, it has been found that exacting studies of flower initiation must use as the index of development, not the appearance of macroscopic flowers or even flower buds, but instead the first detectable morphological symptom of flowering: the appearance of flower primordia at the microscopic level. Actually, the first capacity of the plant to initiate flower primordia is often controlled by very different factors than is the development of the flower primordia into blooms or fruits. Recent studies on the effects of inorganic nutrients on flower initiation have revealed that while nitrogen levels (particularly in relation to carbohydrate levels) have a profound influence on later stages of flowering, they have very little or no influence on floral initiation (Neidle, 1939; Naylor, 1941; Withrow, 1941). As long as photoperiod sensitive plants are receiving sufficient nutrients for survival, they seem to be able to respond to photoperiodic induction. Variations in nutrient levels have not substituted for photoperiodic induction (Cajlachjan, 1944). It seems likely that inorganic plant nutrients must not play a primary role in photoperiodism.

Role of auxins

After the discovery and isolation of auxins, the growth hormones of plants, it was soon observed that they were capable of inhibiting flowering in some cases. Later work confirmed that the inhibition could actually act on photoperiodically induced flower initiation (Bonner and Thurlow, 1949). Instances have been found where apparently high natural auxin contents of plants will exert a similar inhibitive effect (Reece et al., 1946). These facts, coupled with the observation that compounds which antagonized auxin could increase flowering in some plants, led to the idea that there may be two antagonistic hormones in plants—a vegetative hormone encouraging vegetative growth and a flowering hormone encouraging reproductive growth (Galston, 1947). Such an antagonism would explain the observations that auxins inhibit flowering and conversely flowering commonly inhibits vegetative growth. However, it is characteristic of the actions of auxins in growth phenomena, that while high concentrations are inhibitory, low concentrations are stimulatory. This is true in growth

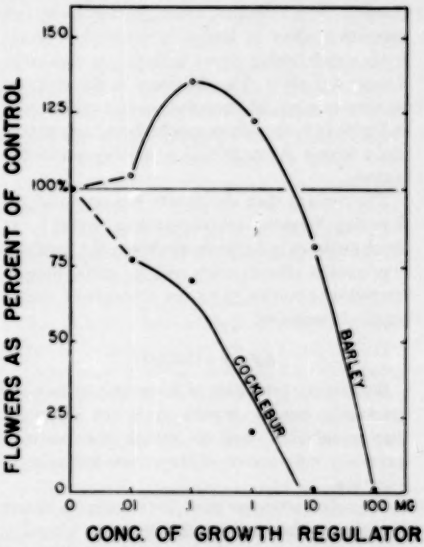

FIG. 6. QUANTITATIVE MODIFICATION OF PHOTOPERIODIC INDUCTION BY A WEAK GROWTH REGULATOR OR AUXIN (BENZOTHIAZOLE-2-OXYACETIC ACID) APPLIED TO THE PLANTS DURING INDUCTION

Data of Klein and Leopold, 1951.

of stems, buds, roots, in apical dominance, in root formation, and in morphological differentiation in general (Thimann, 1938; Skoog and Tsui, 1948). Consequently, the ability of auxins to inhibit flower initiation in some plants is not dependable evidence for concluding that a simple antagonism of flowering by auxin exists. This is brought out especially by the fact that the pineapple can actually be induced to flower by application of small amounts of auxin (Clark and Kerns, 1942). Wintex barley (a long-day plant) can be promoted in photoperiodic induction by small amounts of auxin (Leopold and Thimann, 1949). Furthermore, this promotion effect in barley is obtained at auxin levels which inhibit flower initiation in cocklebur, a short-day plant. The difference in flowering responses to auxin of these two species can be seen in Fig. 6. In both of these species, larger amounts of auxin inhibit flower initiation, or even prevent it entirely.

The concept that the growth hormone and the flowering hormone are antagonistic systems has much evidence in its favor. However, the instances of promotive effects on flowering by auxins pose an interesting question as to the existence of such a simple antagonism.

Role of metabolites

Because the formation of flower primordia must necessarily involve growth, it is not surprising that metabolites used in growth may exert a secondary influence on photoperiodic induction of flowering.

Extensive attempts have been made to induce flowering with solutions of hormones, vitamins, amino acids, sugars and mixtures of growth factors (Sivori and Went, 1944; Hamner and Bonner, 1938). These have all failed with the exception of pineapple which can be induced to flower by application of growth regulators. In no case has any known compound replaced the photoperiodic requirement.

Two instances have been recorded of plant extracts which have induced flowering in photoperiod sensitive plants. Neither of these has yet been shown to be reproducible (Bonner and Bonner, 1948; Roberts, 1951).

Attempts to find secondary influences, or quantitative modification of photoperiodic induction with metabolites, have been more successful. Before discussing secondary effects, it should be mentioned that the requirement for the light period can be modified, or even replaced, by supplying the plants with sugar in darkness (Bonner, 1950). This information supports further the assumption that the action of light in the light phase (discussed under "photoactivation" above) is indeed photosynthesis. Organic acids show the same capacity for substitution for the light period, but are somewhat less effective.

Organic acids are of especial interest as secondary factors in photoperiodism in that their concentration in a given plant is strongly dependent on day-length. Klein and Leopold (1951) have found that the addition of organic acids to plants during photoperiodic induction results in a promotion of floral expression in long-day barley and an inhibition in cocklebur (Fig. 7). Whether these opposite tendencies are common among long-and short-day plants in general has not yet been ascertained. It is of interest, however, that the effects of organic acids on flowering are so similar to the effects of auxins (cf. Figs. 6 and 7).

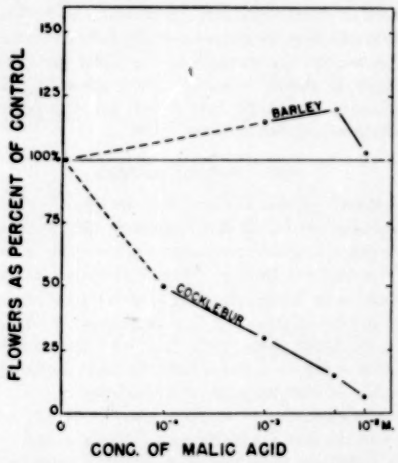

FIG. 7. QUANTITATIVE MODIFICATION OF PHOTOPERIODIC INDUCTION BY MALIC ACID APPLIED TO THE PLANTS DURING INDUCTION
Data of Klein and Leopold, 1951.

That metabolic substrates may be highly important in flower initiation has been shown, particularly by experiments with the long-day plant, henbane (*Hyoscyamus niger*). Infiltration of this plant with sugars can induce flowering under day-lengths slightly shorter than those normally re-

quired for induction (Melchers and Lang, 1942). Slowing of the metabolic catabolism in the leaves at night by subjecting them to low temperature, atmospheres very low in oxygen, or weak light (0.06 f.c.) all bring about flowering under short-day conditions. All of these treatments cause a retardation in carbon dioxide evolution by the leaves (Lang, 1941; Claes, 1947). In henbane the entire photoperiod sensitivity seems to be due to a catabolic process which takes place in the darkened leaves and which prevents flowering. Prevention of such catabolic activity, substituting sugar as a substrate for it, or removing the leaves entirely will all result in flower initiation. It seems likely that henbane is an exceptional case, for attempts to induce other long-day plants to flower by these means have failed.

Changes in the carbohydrate–nitrogen ratio are known to occur after flower initiation. Careful measurement of these changes indicates, however, that the shift follows photoperiodic flower initiation, and good evidence that it is involved in flower initiation is lacking (Murneek, 1948).

Changes in rate of respiration have been observed after the onset of flowering (Roberts, Kraus, and Livingston, 1937; Bode, 1942; Elliot, unp.). In brief, the role of metabolites in flower initiation shows considerable promise for future research, but as yet the subject has only been touched lightly.

Role of growth

As stated in the previous section, since growth is essential to the development of flower primordia it is not surprising that metabolites used in growth or that growth itself may play a role in flower initiation. It is clear that in the absence of growth, as for example during dormant periods, flower initiation cannot take place (Reece, Furr, and Cooper, 1949).

Since growth is prerequisite for initiation, it would seem that flowering might be prevented in some cases by application of a growth inhibitor. This has been done using maleic hydrazide (Klein and Leopold, 1951). Complete prevention of flowering of long-day barley in response to inductive photoperiods has been obtained using as little as eight micrograms of the inhibitor per plant. In this case the inhibitor was demonstrated to be preventing flower initiation by affecting growth and apparently not by inhibiting the photoperiod stimulus.

There is a general tendency for plants to show reduced meristematic activity at the time of flower initiation. This has been observed to be true in many long- and short-day plants, as well as in indeterminate plants. Roberts and Struckmeyer (1948) have suggested on the basis of this information that the flowering stimulus is one which retards growth. Such a proposal is very similar to the idea that the growth hormone and the flowering hormone are opposite and antagonistic. On the other hand, it has been observed in several instances that flowering responses vary quantitatively with growth—or at least with fresh weight. This has been observed in cases where flower initiation has been increased or decreased with such widely different agents as auxins, metabolites, enzymatic poisons and x-irradiation. Each of these agents which increases flower initiation also increases plant weight (Leopold, 1948; Leopold and Thimann, 1949; Klein and Leopold, 1951). The disparity between the observation that meristem activity is reduced at the time of flower initiation and that agents which increase flowering also increase plant weight is an interesting one which remains to be clarified.

Bolting or shooting is another growth function which is linked to photoperiods. A very large proportion of long-day plants are of a rosette form until flowers are initiated, at which time they bolt. This growth function is activated by long photoperiods and has been shown to be independent of flower initiation, at least in the case of *Rudbeckia* (Murneek, 1940).

Another growth phenomenon which is influenced by photoperiods is that of stem elongation in white pine. In this instance growth is promoted by long days, and the long-day response is apparently largely dependent on short nights. Wareing (1950) has found that repetition of short dark periods twice during a 24-hour cycle greatly enhances growth. This is another striking example of the dynamic effect of the dark period in photoperiodism.

THE NATURE OF THE PROPOSED FLOWERING HORMONE

Because the flowering response is the best known photoperiodically controlled function in plants, and because this function appears to be mediated by some carrier which can move about in the plant, it is pertinent to review here the characteristics of this mobile function: the proposed flowering hormone.

Origin

Since the photoperiodic perception is primarily through the leaves of plants, and the response to this stimulus can be prevented by removal of the leaves or by preventing translocation out of the leaves, it is clear that the flowering stimulus or hormone must originate primarily in the leaves.

Movement

The translocation of the hormone has been found to take place only in live tissues, as for example phloem, parenchyma, or leaf mesophyll (Moskov, 1939). Non-living cells such as xylem or steam-killed tissues cannot transport the stimulus. In fact, diffusion across surfaces closely pressed together cannot take place unless living connection is made (Withrow and Withrow, 1943). The hormone cannot apparently be transmitted through water, although some earlier workers believed they had found that it could. Translocation can be deterred by low temperatures or metabolic poisons, and this is not unexpected since translocation is only through living cells. In contrast to the growth hormone, its movement is non-polar and can take place in any direction. In general, the flowering stimulus must be translocated in relatively large amounts, or at least swept along with a relatively large flow of plant materials. This is indicated by the fact that a localized photoperiodic induction generally can not be transmitted through the bulk of the plant unless the receptor portion is defoliated, darkened or otherwise starved. Under these conditions active flow of materials presumably takes place from the induced portion (carrying on normal photosynthesis) to the defoliated or darkened portion. A striking case of this is seen in sugarbeet, where an induced beet may be grafted to a non-induced beet, and the non-induced receptor will stay entirely vegetative unless kept in the dark while the donor is kept lighted (Stout, 1945). In this regard, movement of the flowering stimulus closely parallels movement of some virus infections.

The study of movement of the flowering stimulus across grafts has brought to light some good evidence that the flowering hormone is the same in all the different photoperiodic classes. Both long-day and indeterminate species can induce flowering in a short-day plant across a graft. Furthermore, both long- and short-day plants can stimulate a biennial to flower in the first year (Melchers, 1937).

Persistence

Evidence as to the persistence of the flowering stimulus is often obscured by inhibitory influences of non-inducing photoperiods. However, two points seem to be clearly established. Firstly, the effect of a given inductive cycle can persist in the plant and be added to, after an interim, by other inductive cycles. For example, plantain requires 15 to 26 long-days for flower initiation, and these can be experienced consecutively or a few at a time with short-days interspersed (Snyder, 1948). Secondly, once the threshold for flower initiation has been reached the flowering response can sometimes continue for an extended period of time. For example, a cocklebur plant induced with just seven short days has been recorded as initiating flowers for the next 18 months. Flower initiation can continue even after the leaves which were originally induced have died off or have been removed (Hamner and Bonner, 1938).

A dramatic case of persistence and spread of the flowering stimulus has been reported by Bonner (1950), who grafted an induced cocklebur leaf onto a vegetative plant causing flowering, then grafted another leaf from the receptor plant onto another vegetative plant and so on for a total of five transplants of the flowering stimulus. From the information at hand, then, it appears that the product of photoperiodic induction is relatively stable and persistent.

Inhibition and Destruction

In nearly all species of photoperiod sensitive plants, expression of the flowering stimulus is inhibited by leaves receiving non-inductive day-lengths (Moskov, 1936). The only two exceptions which have been found to date are cocklebur and a tropical amaranth (*Amaranthus caudatus*) (Hamner and Bonner, 1938; Fuller, 1949). The inhibitory action of leaves receiving non-inductive day-lengths can be removed by severing the leaves so treated from the plant, or, in the case of short-day plants only, by placing the leaves in total darkness.

The inhibitory effect exerted by leaves of short-day plants receiving long photoperiods is proportional to light intensity and day length. The weaker the intensity of light, and the shorter its duration, the less the inhibition exerted. Introduction of sugar solutions into the petioles increases the inhibition effect. Cajlachjan (1947) has concluded that the inhibition is a function of sugars in the leaves. As might be expected, inhibitions by leaves

of long-day plants show rather opposite tendencies: inhibition is *inversely* proportional to day length, and is reduced by the application of sugars.

In studies of this sort it is difficult to know whether one is really dealing with factors modifying the inhibitor or whether instead one is dealing with secondary factors in flower initiation per se. Thus a conscientious listing at present of factors which apparently modify the inhibition effect would be of little service in clarifying the nature of the inhibition

There remains a real possibility that a specific compound which inhibits flowering may be formed by non-inducing day-lengths. As already described above, the photoperiod requirement of henbane appears to be primarily the requirement for non-formation of a flowering inhibitor. In henbane flowering can occur in any photoperiod which will not permit formation of this inhibitor in the leaves (Lang and Melchers, 1943).

THEORIES TO EXPLAIN PHOTOPERIODISM

The accumulation of information over the last 30 years has led to several interesting theories as to the nature of the photoperiodic stimulus in general or of the flowering stimulus in particular.

As has already been mentioned, Roberts and Struckmeyer (1948) have proposed that the flowering hormone may be a compound which slows meristematic growth and promotes maturation instead. This interesting idea is supported by the general tendency for dicotyledonous plants to experience a reduction in meristem activity and—in short-day plants—a retardation in stem elongation upon being induced to flower.

Bonner (1950) has proposed that the flowering hormone may be protein in nature. He has pointed out that many of its characteristics parallel those of a virus such as curly-top virus in sugar-beet, particularly with respect to translocation, insolubility, and perhaps continued formation. Proteins such as the virus mentioned must be swept along by active translocation, they show no polarity of movement, and they are not obtainable with solvent extraction. Proteins such as nucleoproteins are capable of continued formation in plants once an initial amount has been produced. As evidence suggesting that the flowering stimulus may be able to form even after photoperiodic induction has ceased, Bonner cites his graft experiments in which leaf grafts carried the flowering stimulus so five plants in succession without renewal of the photoperiodic stimulus.

Lang and Melchers (1943) have demonstrated that the photoperiodic response of long-day henbane is due to an inhibitor of flowering produced in the leaves during the long nights. Experiments with other long-day plants, however, have shown that photoperiod mechanism does not constitute the primary control of flower initiation in most long-day plants.

Hamner (1942) has proposed a scheme for the description of flowering reactions of short-day plants. He does not attempt to fit his proposal to the reactions of long-day plants. He has shown that each light period makes possible the effectiveness of the subsequent dark period. Therefore, it seems logical that some condition, "A", is formed in the light. A second condition, "B", which is destroyed by light, is then formed in the dark. Because the photoperiodic response is persistent over a period of time, it seems that the final product of the photoperiodic cycle must be light-stable. Hence it is proposed that "A" and "B" give rise to a third condition "C", which is presumed to be the proposed flowering hormone. "A" and "B" are relatively unstable and therefore capable of only limited summation. "C" is stable and can be accumulated. By this scheme, a short-day plant must first experience enough light to build up a threshold value of "A". Then it must have darkness to build up a threshold value of "B". Then "A" and "B" give rise to "C". The sequence must be repeated several times in most plants before sufficient "C" is accumulated for flower initiation.

Borthwick, Parker, and Hendricks (1948) have proposed a scheme, or "working hypothesis", which is stated in their own words as follows:

> "Floral initiation is controlled by an active substance produced in the leaves of the plant. This substance or an intermediate in the course of its production is subject to photosensitized destruction in the leaf. The active substance must reach an adequate concentration to cause floral initiation but is inhibitory at relatively higher concentrations."

The hypothesis assumes that the flowering hormone or "stimulus" may be produced both in light and in darkness, but more rapidly in the dark. Short-day plants would be expected to have a relatively slow rate of production or perhaps a high rate of destruction, and so require the long nights in order to reach the minimum threshold for

flowering. Indeterminate plants may have a faster rate of production, so they are independent of the long night. Long-day plants may have a still higher rate of production, and if they experience long nights the concentration of the "stimulus" passes above the maximum threshold for effectiveness. By this hypothesis plants will initiate flowers only if the concentration of the "stimulus" is above the minimum threshold and yet below the maximum threshold.

The hypothesis seems to be compatible with that of Hamner, but adds the concept that the same stimulus which must be accumulated for flower initiation of short-day plants may prevent initiation of long-day plants by being present in relatively higher concentrations. This concept that the flowering stimulus may be promotive at medium concentrations and inhibitory at high concentrations finds a close analogy in the action of the growth hormone. Growth of any given organ or tissue may be stimulated in growth by medium concentrations of the growth hormone, or conversely, inhibited in growth by higher concentrations.

The Borthwick hypothesis is supported by four lines of evidence: 1) the capacity for inducing plants of different photoperiodic classes across grafts suggests that the flowering hormone may be the same in all classes; 2) the close similarity of action spectra for the interruption of long dark periods in the different classes suggests that while the hormone may be the same, the direction of its action may be opposite in the two classes; 3) the oppositeness in requirements of the two classes is borne out further by the strong correspondence between factors which will promote flowering in one class and will inhibit flowering in the other; 4) the discovery of the photoperiod requirements of some plants for intermediate day-lengths—not longer than a certain amount and not shorter than another—supports the hypothesis admirably by demonstrating that both a minimum threshold and a maximum threshold may be operative in the same plant.

There are two lines of evidence which do not readily fit into the Borthwick hypothesis. The first is the evidence that inductive photoperiods applied to long-day plants can be additive in their effects even when separated by non-inductive short days. If short days cause accumulation of the active substance in super-threshold amounts, then the rather negative effect of a long day on the amount of this substance would not be expected to persist when followed by short days again. The second is the evidence that in one case at least a short-day species has been found capable of inducing a long-day species across a graft (Melchers, 1937). While the Borthwick hypothesis is not invalidated by these situations, still they pose interesting inconsistencies.

Conclusions

In conclusion, it is clear that the understanding of the physiology of photoperiodism in plants is undergoing rapid development. As in many fast-growing things, there is a considerable lack of coordination. Some sections of the field are considerably more developed than others. As Thimann (1948) has pointed out, dramatic clarification of a whole sector of the field may come at any time. Workers are actively searching for the pigment responsible for the photoinactivation reaction, for chemical agents which will alter flower initiation, for metabolic processes directly involved in photoperiodism, and of course for the flowering stimulus itself. A major success in any of these endeavors or other similar studies may alter the whole field of photoperiodism.

A growing trend in the study of photoperiodism appears to be the beginning of the establishment of tieups between empirical knowledge of this field and fundamentals of plant growth and metabolism. Such tieups have already been made in the fields of ion uptake and transfer, and of auxins and growth regulators. It is hoped that knowledge of photoperiodism, too, will find its basis in the fundamentals of plant growth in the near future.

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THE LATERAL LINE SYSTEM OF SENSE ORGANS

By MARGARET R. WRIGHT

Department of Zoology, Vassar College, Poughkeepsie, New York

TO students of the special senses the lateral line system of sense organs offers a unique and interesting subject, and there is an extensive literature pertaining to it which has never been adequately reviewed. An attempt will be made here to survey briefly the literature on the distribution, structure, function, development, induction, maintenance of structure, regeneration, and metamorphosis of the lateral line system of sense organs, with particular reference to the Amphibia.

GENERAL DESCRIPTION OF THE LATERAL LINE SYSTEM

The lateral line system of sense organs is present in the cyclostomes, fishes, aquatic larval stages of amphibians, and in various degrees of development in some adult Amphibia. The antiquity of the system is demonstrated by good evidence of lateral line canals in agnathous Heterostraci (perhaps the oldest of all vertebrate orders) of late Silurian and early Devonian deposits (Romer, 1945, Fig. 21). Of the Devonian placoderms the Acanthodii, Arthrodira, Macropetalichthyida, and Antiarchi all have grooves in the armor indicating a well developed lateral line canal system (Romer, 1945, Figs. 26, 28, 30, 39, 35, 37). Canal systems are, of course, also well represented in the fossil Chondrichthyes and Osteichthyes.

In modern agnathous forms the lateral line system consists of linear rows of sense organs in shallow pits (Johnston, 1902), but the characteristic fish type of system is a series of canals enclosing sense organs and opening to the surface at intervals by means of small pores. There is, however, considerable variation within the group. Some fishes have superficial organs in addition to those in the canals, while others have the organs in shallow surface grooves rather than in deeper canals. This variation is illustrated by the disposition of organs in dipnoans, as described by Kingsbury (1895). In *Lepidosiren* the system is one of the superficial lines of organs; in *Ceratodus* it is sunken in canals; and in *Protopterus* it is intermediate in nature, being partly open and partly closed.

The characteristic amphibian type of lateral line system is a series of lines of superficial sense organs. There are no canals present in modern forms, although the primitive amphibians of the Carboniferous, the Labyrinthodontia, probably had canals. Grooves suggesting head canals are evident on many fossil skulls (Romer, 1945, Figs. 96, 97).

In general, the degree to which the lateral line system is developed in modern Amphibia varies directly with the degree to which the animal depends upon an aquatic environment (Wright, 1938). For example, in the Urodela, the terrestrial adult *Plethodon c. cinereus* has no lateral line system and there is no aquatic larval stage. Dent (1942) was unable to find any "neuromasts" at any time during the development of this form. On the contrary, larval *Salamandra atra*, in which the larval period is spent entirely within the maternal oviducts, has well developed lateral line organs (Escher, 1925). In *Triturus v. viridescens*, lateral line organs are present both in the larval and in the aquatic adult stages, though covered by epidermal cells in the sexually immature terrestrial red eft (Kingsbury, 1895; Dawson, 1936). A persistently aquatic form such as *Amphiuma* has a strikingly well developed system throughout life. Somewhat parallel conditions exist in the anurans. For example, the tropical *Eleutherodactylus* has no aquatic stage and no lateral line organs (Lynn, 1942); the South African frog, *Arthroleptella*, has no aquatic larval stage, but lateral line organs are present in the embryo (de Villiers, 1929); the common species of *Rana* tadpoles possess lateral line organs which are lost at metamorphosis; and the aquatic *Xenopus* and *Pipa* have well developed systems which are maintained in the adult. However, there are exceptions to the rule. The South American toad, *Pseudis*, and the caecilian, *Typhlonectes*, are aquatic forms which apparently lack a lateral line system (Escher, 1925).

W. Gardner Lynn has kindly sent his sectioned material of *Elentherodactylus* for examination. The specimens of *Pipa* and *Xenopus* examined were lent through the courtesy of the American Museum of Natural History. Sections of the skin from a specimen

of *Xenopus*, lent through the courtesy of The Peabody Museum, Yale University, were made to verify the sense organs.

DISTRIBUTION ON AMPHIBIANS

The distribution of the lateral line system of sense organs on the anuran tadpole is illustrated in Fig. 1. Three lines are present on the side of the body, dorsolateral, median, and ventrolateral in position (D,M,V). The mid-body line (M) has the greatest development. It extends from a short distance behind the eye to the tip of the tail, and curves dorsally on the posterior part of the tail to follow the dorsal edge of the muscle mass. The ventral line (V), beginning in the midventral region, extends laterally, curves dorsally over the spiracular opening, and extends posteriorly to the tail but not onto it. It is therefore dorsal to the region of the insertion of the future forelegs, whereas in urodeles it is usually ventral to the forelegs. The dorsal line (D) is in close association with the mid-body line anteriorly on the trunk, but in the tail region it is confined to the dorsal fin. It extends a third or more of the length of the fin and is located about midway between the level of the edge of the muscle mass and the dorsal fin margin. In urodeles this line is frequently less well developed and may merge with the midline.

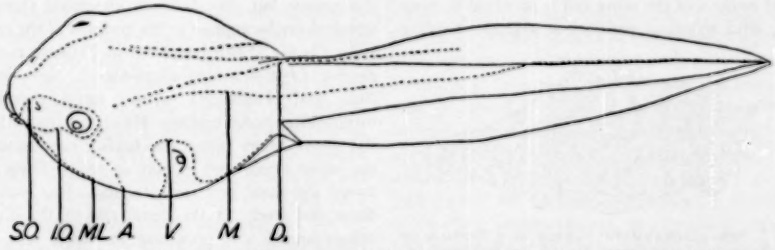

FIG. 1. DIAGRAM SHOWING THE DISTRIBUTION OF LATERAL LINE ORGANS ON AN ANURAN TADPOLE
A, angular; D, dorsal; I.O., infra-orbital; M, median; M.L., mandibular; S.O., supra-orbital; V, ventral line.

The supraorbital line (SO) extends from the region just posterior to the eye dorsally over the eye and on the snout median to the external naris. The infraorbital (IO) line extends from its junction with the supraorbital ventrolaterally beneath the eye and on the snout lateral to the external naris.

The mandibular line (ML) extends, on the ventrolateral aspect of the head, from the level below the eye anteriorly toward the mouth. Immediately posterolateral to the mouth it makes an acute angle and arcs posteromedially on the ventral surface. The angular line (A) extends laterally from near the junction of the supra- and infra-orbital lines and curves ventrally so meet that of the opposite side in the midventral region. In urodeles the angular line connects the infraorbital line with the mandibular line just posterior to the angle of the mouth. Also in urodeles a hyomandibular line extends posteriorly from the junction of the supra- and infra-orbital lines and is continuous with the ventral hyomandibular line, which curves anteriorly on the ventral surface toward the midpoint of the lip.

In anurans, as well as in some urodeles, the lines are made up of clusters of organs. In many urodeles they are lines of single organs. For a modern account of the homologies of the various lines of sense organs in amphibians and fishes, the reader is referred to the comprehensive work of Stensiö (1947) and to the extensive bibliography to be found there. Stensiö's analysis is based largely upon embryological evidence.

HISTOLOGICAL STRUCTURE OF THE LATERAL LINE SENSE ORGANS

Since the original histological demonstration of the sensory nature of the lateral line sense organs of the canals of bony fishes by Leydig (1850), there have been many published descriptions of the distribution and fine anatomy of these sense organs in various fishes and amphibians. Some of the works of historical interest are: Schulze, 1861, perch and *Triton*; Garman, 1888, Chondrichthyes; Allis, 1889, *Amia*; Guitel, 1891, *Lophius*; Ewart, 1892, elasmobranchs; Pollard, 1892, nematognaths; and Kingsbury, 1895, amphibians and dipnoans.

These studies, supplemented by more modern cytological works, such as those of Charipper

(1928) and Chezar (1930) on amphibians and of Denny (1937) on *Fundulus*, reveal a similar structure in the sense organs of various forms. In some, the organs are confined to the epidermis, whereas in others they are partially embedded in the dermis, but the fine structure of the cells of the organs is essentially similar in all. A general description based upon the findings of the authors cited above follows; minor variations from this structure occur in different forms.

The organs are usually pear-shaped in cross section and are made up of four different types of cells. The sense cells are club-shaped, tapering toward the free surface of the organ, and each bears a hair-like process at its tip. Mitochondria appear to accumulate at the distal end. The large, ovoid nucleus of the sense cell is proximal in position, with spherical perinuclear granules tending

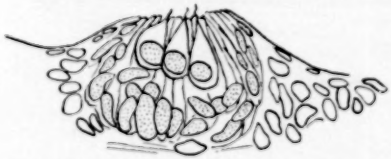

FIG. 2. SEMI-DIAGRAMMATIC SKETCH OF A SECTION OF A LATERAL LINE SENSE ORGAN OF TRITURUS V. VIRIDESCENS TO SHOW THE CENTRAL POSITION OF THE SENSE CELLS

to concentrate at the proximal pole. There have also been described prominent, bright orange, protein granules of unknown origin and function within the sense cells of freshly caught anuran tadpoles (Bedell, 1939; Speidel, 1949). The sense cells are located in the center of the organ surrounded by the various supporting elements (Fig. 2).

The supporting cells are of three types; basal, sustentacular, and mantle cells. The basal cells are long and taper distally as they extend between the sensory or the sustentacular cells. They possess large oval nuclei. The slender, spindle-shaped sustentacular cells also extend around and between the sensory cells. Their nuclei are elongate. The mantle cells form a close-packed protective layer around the periphery of the organ. They may be in two or more layers, and their nuclei are large and oval. In addition to the mitochondria found in the basal, sustentacular, and sensory cells, the mantle cells have single, coarse, axial fibrils. Charipper (1928) and Chezar (1930) believed these to be of mitochondrial origin.

The published descriptions of the nerve terminations within the organs are not in complete agreement. Retzius (1892) saw no continuity between the nerves and sense cells of the lateral line organs in larval *Salamandra*. The nerve endings appeared as free terminal brushes around the cells. Bunker (1897) described extracellular nerve terminations in *Ameiurus*, and Heilig (1912) also described similar nerve endings in both fish and amphibians. Johnson (1917) found that branches of the nerve twigs pass between the sense cells and end in terminal knobs on the surfaces of these cells in *Mustelus canis*. Charipper (1928) on the contrary, described intracellular nerve endings in the lateral line organs of *Necturus maculosus*. Larsell (1929) could find no evidence of such endings in *Ambystoma* but, like Johnson, described them as terminal knobs applied to the surfaces of the sense cells. Chezar (1930), working on *Triturus v. viridescens*, *Cryptobranchus allegheniensis*, *Siren lacertina*, and *Amphiuma means*, again described intracellular nerve endings. He stated that lateral line nerve fibers pierce the basilar membrane of the sense organ and extend as naked fibers between the basal and sustentacular cells. Some of these end freely at the distal end of the organ, others branch and penetrate the sense cells and ramify there to form basket-like structures closely associated with the granules around the proximal portion of the nucleus. All of the above descriptions are based on histological study. Nerve terminations in living sense organs are difficult to see, but Speidel has made some fine observations on regenerating lateral line nerve fibers in amphibian tadpoles. His drawings appear to show extracellular endings, although he makes no definite statement to support either view (Speidel, 1947). Due to the lack of uniformity in the published descriptions, no general statement can fairly be made concerning the precise nature of the lateral line nerve terminations. Whether the variations indicated above reflect differences among organisms or differences in techniques used is a problem for the future. Parenthetically it may be recalled that intracellular nerve endings have been claimed to exist in some other systems, as, for example, in the tastebuds of the hedgehog (Boeke, 1925) and in the epidermis of various reptiles (Jaburek, 1927).

FUNCTION OF THE LATERAL LINE SYSTEM

For many years after the discovery of the lateral line canal system by Stenonis (1664), its function

was considered that of secreting mucus. Though Jacobsen (1813) postulated that the system was a sensory apparatus for the transmission of vibrations from water to nerves, it remained for Leydig (1850) to present definite histological evidence before the sensory nature of the system was generally recognized.

It has been suggested by Smith (1930), from his experiments on the canal system in goldfish, that chemical as well as physical changes in the environment may be detected by the sense organs but apparently there is no other recorded evidence for their action as chemoreceptors. Most of the attempts to analyze the function of the lateral line system have revealed that it is sensitive to water vibrations. Schulze (1870) thought that mass movements of water, or the movements of the animal through the water, were effective stimuli. Fuchs (1895) believed that the system recorded changes in hydrostatic pressure, and Lee (1898) concluded that the function was that of equilibration, analogous to that of the ear. Hofer (1908) found that weak currents, minute streams of water, stimulate the lateral line system and Parker (1904) found that water vibrations of a slower frequency than those affecting the ear are effective in fish. Dye (1921) and Nicholas (1922) showed that *Necturus* and *Ambystoma tigrinum*, respectively, are sensitive to low frequency water vibrations. Scharrer (1932) demonstrated experimentally that water vibrations stimulate the lateral line organs of *Ambystoma maculatum*. The experiments of Dye and of Scharrer will be briefly reviewed to indicate the type of evidence brought to bear on this problem.

In the experiments of Dye, the necturus was placed in a wire cage, suspended in an aquarium. A wire stretched across one side of the cage was made to vibrate at known frequencies (129/sec. or less), and the responses of normal animals and of animals in which the lateral line nerve connections had been severed were observed. Changes in the rate of gill movements and sudden movements of the animal form the normal response. Such responses were not observed in those animals without functional lateral line nerve connections. When regeneration of the nerves was permitted, normal responses were again obtained.

In Scharrer's experiments, study was made of the animals' responses to directed streams of water. Possible visual influence was eliminated by extirpation of the eyes. When streams of water were directed toward the eyeless animal, the characteristic response was a snapping reflex toward the stream. When an eyeless animal was tested, which had also had the primordia of the lateral line on one side of the head removed in the embryo, a positive response was obtained from the control side, but not from the side devoid of lateral line organs. Scharrer also found that animals deprived of both eyes and nose were capable of capturing living *Enchytraeus* quickly, provided the *Enchytraeus* moved about so as to cause irregular streams in the water. The salamanders were not able to capture them if the worms remained quiet. Detwiler and Copenhaver (1940) also noted that the snapping responses of salamander larvae deprived of both eyes and nasal placodes were normal. They questioned the importance of ocular responses of normal animals in obtaining food and suggested that the snapping reaction to moving objects may be entirely a response to the stimulation of lateral line sense organs. Study of the nervous system of the scabbard fish, a deep sea predator, tends to confirm this point of view. The scabbard fish has enlarged lateralis centers in the medulla and no comparable enlargement of visual or olfactory centers (Evans, in Pumphrey, 1950).

Many of these efforts to analyze the function of the lateral line system have stressed function relative to carnivorous habit. Since anuran tadpoles are primarily vegetarians, it is more difficult to understand the role of the sense organs in them. Perhaps there are continuous spontaneous discharges from the sense organs to their nerve supply, as described below for fishes.

Hoagland (1932) reported that the lateral line nerve of *Ameiurus* seems to be in a state of continuous spontaneous activity, but that the rate of discharge can be altered experimentally. He found that an increase in temperature led to an increase in the rate of spontaneous discharge and suggested that the sense organs might act as thermal receptors. Moreover, pressure on the skin overlying the canal caused an increase in the frequency of discharge, and water ripples caused a fluctuation in rate. Hoagland also observed that when a tuning fork was pressed on the outside of the dish, the discharging sense organs became synchronized, but this synchrony did not correspond to the rhythm of the tuning fork. When the tuning fork was stopped, the synchronization also stopped. He suggested that the sensory hairs possibly might be cilia which, by continuous beating, may con-

tinually excite the sense cells and therefore be responsible for the observed spontaneous discharges.

Denny (1937), in her account of the lateral line system of *Fundulus heteroclitus*, described a jelly-like mass attached to the sense organs enclosing the sensory hairs. Such a cupula was not found upon the organs of *Ameiurus*. The spontaneous activity of the lateral line nerve shown in *Ameiurus* does not occur in *Fundulus*. Since the cupula is of a stiff consistency, Denny believed that the enclosed hairs would not be able to beat. This, then, might be taken as evidence in favor of Hoagland's suggestion that it is the beating of the hairs which is responsible for the spontaneous activity observed in the catfish.

In the previous section it was shown that the sense cells of all amphibian lateral line organs possess hairlike processes. Perhaps, though this has not yet been demonstrated, the lateral line nerves of Amphibia are also in a state of continuous spontaneous activity through this form of stimulation.

THE DEVELOPMENT OF THE LATERAL LINE SYSTEM

The first experimental approach to the study of the development of the lateral line system of sense organs was made by Harrison (1903), when he demonstrated in the living animal that the sense organs develop from rudiments located on the head of the amphibian embryo. A free translation from the report of these first observations follows:

> "When, for example, the head part of the nearly black embryo of *Rana sylvatica* was joined to the tail part of a light brown embryo of *Rana palustris* in a specimen of normal form, a fine dark streak appeared after some time in the light background of the palustris hind quarters. This streak, which proved to be the heavily pigmented rudiment of the lateral line, extended gradually to the tip of the tail and separated itself into a series of pigmented dots, the individual lateral line sense organs, which are completely like the sense organs of normal sylvatica embryos. We have here a striking proof for the theory that the lateral line organs of the head and tail develop from a rudiment which descends from the head and which reaches the remote body regions by migration" (p. 35).

These rudiments were known to the older morphologists, but it had not been demonstrated that an actual migration of cells took place in the formation of the sense organs. For example, Beard (1884) stated that in the embryo of *Salmo fario*:

> ". . . the first appearance of the lateral line consists in the splitting off of certain of the cells of the inner epiblast layer. This separation takes place at the level of the notochord. It commences in the region of the neck just behind the ear capsule and opposite the hyoid arch. At its point of origin it is broad, and is at first, short, but soon grows back longitudinally along the whole length of the body. This cord of cells gives origin to the sense organs of the lateral line" (p. 123).

This description implies a progressive splitting off of material from the epiblast rather than an active posterior migration of that material. Beard also believed that the sense organs are segmentally arranged, and that a cord of cells persists and connects the organs.

Platt (1894, 1896) observed a pattern of primitive lines of surface thickenings on the head and body of *Necturus* and interpreted these as an early morphological indication of the lateral line system. She believed that parts of this pattern are retained as the definitive system. Landacre (1926) noted a similar pattern of primitive lines in *Ambystoma jeffersonianum* and offered the suggestion, but with caution, that they might be phylogenetically old sensory lines and that the migratory placodes of the more highly specialized recent system may use these old lines as pathways. However, Stone had suggested (1922) and later proved by experiments (1928b) that these transient primitive thickenings are the result of mechanical molding of the ectoderm by underlying structures and that they are not a necessary prerequisite for the formation of lateral line sense organs.

Landacre (1921), while studying the fate of the neural crest, noted that the lateral ectoderm of the urodele embryo gives rise both to the lateral line placodes and to the lateral line ganglia. He traced (1928) the development of the system by study of serial sections of staged embryos of *Ambystoma jeffersonianum*. Stone (1922) described the normal development of the lateral line system in *Ambystoma maculatum* (*A. punctatum*) and included the first experiments done to analyze their development since those of Harrison. Therefore at this time, by the use of experimental methods, it was definitely established that the entire lateral line system, both sense organs and nerves, is developed from ectodermal placodes on the head of the early amphibian embryo and that the neural crest makes no contribution to the system (Stone, 1922). The methods employed by Stone (1922, 1923, 1924, 1925, 1928a, 1928c, 1928d, 1929, 1931,

1933a, 1935, 1937) in analyzing the various phases of development of the lateral line consisted of the following general types of experimental procedure: vital staining with Nile blue sulfate; extirpation, heterotopic transplantation, reciprocal exchange, and rotation of placodes; and the observation of living, vitally stained material. A general account of the development of the lateral line system of amphibians, based upon this work, follows.

The various lines of sense organs appear to have separate origins, but all are formed from placodes on the head which migrate to form the definitive lines (Stone, 1922). The development of the supraorbital and midbody lines is described here in order to illustrate the entire system. The primordia of these lines and their associated ganglion cells first appear in close relation to the primordium of the inner ear, as the acoustico-lateralis thickening, and it may be that they are induced by the ear (Stone, 1931). The preauditory and postauditory placodes are ectodermal thickenings extending anteriorly and posteriorly, respectively, from the auditory placode. The anterior portion of the preauditory placode migrates, under the surface ectoderm anteriorly and passes dorsally over the optic cup. During its migration it becomes progressively smaller, due to the dropping off of groups of cells along the way. These cells eventually differentiate to form both the sensory and the supporting cells of the primary lateral line sense organs of the supraorbital line. The posterior portion of the postauditory placode migrates, in similar fashion, posteriorly to the tip of the tail to form the midbody line of primary sense organs.

The posterior portion of the preauditory placode contributes cells which differentiate into the lateralis ganglion cells of cranial ganglion VII. The dendritic processes from these cells innervate the sense organs of the supraorbital line. The anterior portion of the postauditory placode similarly contributes to the vagus. Its fibers innervate the sense organs of the midbody line.

"Defect experiments" were used to demonstrate the fate of the placodes (Stone, 1922). Removal of the preauditory placode resulted in the absence of the supraorbital line of sense organs. The superficial ophthalmic nerve (VII) was also lacking and the lateral line ganglion of VII was small. The infraorbital series of organs was present and was innervated by fibers from this small ganglion. The hyomandibular, ventral hyomandibular, and mandibular lines of sense organs, and the lateralis ganglion of VII which supplies them, were also present. This, then, indicates a separate origin of the supraorbital line from the other lines of organs anterior to the ear. Removal of the postauditory placode resulted in the absence of the midbody line and the normally associated ganglion cells of the vagus. The complete removal of all lateral line primordia posterior to the ear resulted in the complete absence of the occipital group, the lateralis cells of the glossopharyngeus which normally supply that group, the three body lines, and the lateralis cells of the vagus. Experiments involving the removal of lesser amounts of primordial material gave evidence for the separate origin of the occipital, dorsal, ventral, and mid-body lines.

Other ectodermal thickenings upon the head apparently cannot take over the function of a lateral line placode. Stone (1928c, 1929) exchanged the ophthalmic and lateral line placodes and found that neither could assume the function of the other. However, one placode of general cutaneous function may be substituted for another (ophthalmic and gasserian placodes exchanged, Stone, 1924) or one lateral line placode may be substituted for another (Stone, 1925, 1928d). In these experiments the transplanted placode assumed the function characteristic of its new position.

It was also demonstrated that the polarity and direction of growth of the lateral line placodes is established shortly after closure of the neural folds. When the preauditory placode was transplanted, rotated 180 degrees, to the position normal for a postauditory placode, the morphological anterior portion, which was then directly posteriorly, migrated posteriorly (Stone, 1928d). Similar demonstration was made for the postauditory placode. Stone (1923) had previously found that after Harrison stage 23, if the anterior and posterior poles of the postauditory placode were reversed without reversing the dorsoventral axis, the midbody line failed to grow posteriorly, but the morphological posterior end of the placode migrated anteriorly to form a line of sense organs. It was thus clearly shown that the polarity of the placodes was already established in the stages used (Harrison stages 23–27).

Although the migration of the placodes can be studied by use of serial sections, the best observations have been those made upon living material (Stone, 1933a). In these experiments a postauditory placode from an embryo stained with Nile blue sulfate was grafted in place of the host's

excised postauditory placode in both urodele and anuran embryos. The process of migration of cells was followed in the living animals. The movements and differentiation of individual cells were watched by use of the high power of the microscope. The blue primordium was seen migrating down the side of the body underneath the two-layered ectoderm and leaving clumps of blue cells in its wake. The pressure of the moving primordium pushed the inner layer of ectodermal cells aside and bulged the surface ectoderm. Except where clumps of blue cells had been left, the cells of the inner layer regained their former position. The surface ectodermal cells, however, which overlay these blue clumps became thinner. They were slowly pushed aside to expose the blue cells to the surface. The blue cells differentiated both into the sensory and supporting elements of the sense organs. There was never any contribution to the structure of the sense organs by the unstained host's cells. These observations agree with those of Harrison (1903) made on the sylvatica-palustris compound embryos mentioned earlier.

It was previously noted that the lateral lines of anurans and some urodeles are composed of lines of clusters of organs. These clusters form by a budding process from the peripheral supporting cells of the primary organs (Stone, 1933a, 1935, 1936, 1937). No sensory cell contribution has been noted. Apparently both the sensory and supporting elements of the bud organs are derivatives of primary supporting cells. All poles of a primary organ are capable of giving rise to bud organs, but the pole which is most likely to do so is that which is directed toward an area of rapid proliferation. The normal method for increasing the length of the midbody line, as the tail grows, is a similar budding process. A second method of organ reproduction has been likened to binary fission (Speidel, 1948) and is common during the growth of the animal. The two organs resulting from such division are of approximately equal size.

Lateral line placodes have been found in some of the fishes. As already mentioned, Beard (1884) described the sense organs as arising from cellular material which separated from the epiblast. Wilson (1889) and Clapp (1898) also described lateral line primordia in fishes. Johnson (1917) described a migratory primordium which formed the lateral line organs in the canals of selachians. He also showed that accessory organs appeared in addition to the canal organs, and though he did not thoroughly study their method of formation, it seems likely that there may be a process of budding similar to that found among the amphibians.

Landacre (1910) and Landacre and Conger (1913) described the preauditory and postauditory placodes of *Ameiurus* and *Lepidosteus*, respectively. However, they believed that these placodes were not responsible for the development of the lateral line organs. They described a degeneration of the preauditory placode prior to the development of the sense organs (1913). In the light of the more recent research upon amphibians, it seems wise to consider the possibility that the disappearance of such a placode may have been due to its migration and related reduction in size, as it left clumps of cells along its pathway.

Bailey (1937) concluded from some experiments performed on *Fundulus* embryos that the lateral line primordium is not necessary for sense organ formation. It may be well here to examine these experiments critically. The method for removal of the primordial material was that of puncturing the chorion and the embryo by using a glass needle. Then pressure was applied, by forceps, to expel the cellular material. The amount so expelled was regulated by the degree of pressure applied. Of 74 cases that involved the removal of a primordium (either preauditory or postauditory), 45 developed normal lateral line organs; in 21, no lateral line sense organs were found; and in 8 animals there were fewer organs developed than the normal supply. Bailey concluded (p. 191):

> "The experimental results indicate that lateral-line sense organ differentiation in *Fundulus heteroclitus* is not necessarily dependent upon tissue genetically related to the primordium. The experiments do not prove that the lateral-line primordium does not give rise to the sense organs but they do show that in the absence of the primordium, sense organs develop."

In view of the variability shown here, it seems reasonable to question whether or not the method used was adequate to *prove* that the lateral line primordia were entirely removed, and thereby to prove that sense organs develop in the absence of such primordia. More recent evidence (Holmgren, 1940; see also discussion in Stensiö, 1947) indicates that the developmental mechanism in fishes is essentially similar to that in amphibians, though the early stages are less well known.

INDUCTION OF THE LATERAL LINE SENSE ORGANS

The obviously close developmental association of the lateral line sense organs with their specific sensory nerves raises the question of whether or not there is an induction system involved. It has been demonstrated that the development of the primary sense organs can be independent of lateral line nerve connections in the Amphibia (Harrison, 1903, 1924; Stone, 1931). A migratory placode (sense organ anlage) is dependent upon the presence of the ganglionic primordium only until migration begins. After the initiation of migration, the further developmental process shows no such dependency. The ganglionic primordium may be removed entirely without altering the process of development of the primary sense organs. Or, a migratory placode may be transplanted to an atypical position and there lay down a series of normal lateral line organs. On the basis of these experiments it seems clear that lateral line nerve connections do not play a necessary inductive role in the differentiation of the primary lateral line sense organs in Amphibia. It has also been demonstrated that the budding of accessory organs from the primary organs is independent of specific nervous influence (Stone, 1931, 1937).

It might still be argued that the lateral line nerve *can* induce the formation of sense organs whether or not this is a necessary process in normal development. Brockelbank (1925) claimed that ordinary epithelial cells in the catfish respond to the inductive action of growing lateral line nerve fibers by transforming into lateral line organs. This conclusion was based on her observations of regenerated lateral line organs in histological preparations. She claimed that these organs occupied the positions of previously existing organs which had degenerated after nerve section. She correlated the reappearance of organs in these positions with the regeneration of the nerve fibers. However, she stated that in the process of degeneration of denervated sense organs, the supporting elements are the last to go and that "traces of some organs can always be found." Since Stone (1933a) has shown that the entire organ in the urodele apparently differentiates from supporting cells alone, the possibility obviously exists that the regenerated sense organs in the catfish experiments took their origin from the "traces" of old organs rather than from ordinary epithelial cells. Furthermore, mitotic divisions of epithelial cells were not observed.

Mori (1931a, 1931b) and Takebe (1934), working on the lateral line system of the goldfish seemed to assume an inductive action of the lateral line nerve without demonstrating any such action beyond doubt. Bailey (1937) also believed that the lateral line nerve of the catfish induces sense organs. She teased out part of the lateral line nerve and transposed it so that regenerating fibers would extend under the skin into a new region. She found by histological examination of 9 cases, 200 days later, that clusters of new organs had developed in close association with the deflected nerve. Many of these were located near the proximal point of nerve deflection and others were associated with the distal end of the nerve. Some organs lay along the course of the nerve between these two more concentrated areas. It seems reasonable to doubt that these new organs were the result of inductive action because of the proximity of old organs to the regenerating nerve. Though Bailey never observed budding of accessory organs from old organs, which is so common in amphibians, the possibility that the new organs may have been buds has not been disproven. Speidel (1948) suggested the following two simple explanations for Bailey's results. It is possible that fragments of organs might have been transplanted with the deflected nerve. These, by further division and differentiation, could have formed the new organs. And it is also possible that the organs at the proximal point of nerve deflection might have given rise to a typical regeneration placode which could form the new organs.

Anuran material is more convenient for study of this kind, because the lateral line nerve and the sense organs on the surface of the translucent tail fin are readily visible and can be studied frequently over extensive periods of time in a living condition by use of a micro-aquarium on the compound microscope. Therefore all stages of an experiment can be observed, rather than just its end result. An experiment similar to Bailey's nerve transposition was performed on anuran tadpoles (Wright, 1946, 1947). The dorsal lateral line nerve was deflected and allowed to regenerate in an area of the fin possessing no sense organs and the progress of the experiment was observed on nineteen living animals at frequent intervals. A total of 415 observations was made on experiments rang-

ing from 33 to 200 days in duration. No organs related to the regenerating nerve appeared in any case. If induction were of normal occurrence in anuran lateral line development, certainly sense organs would have appeared early in such an experiment, unless there is some unknown difference between developing and regenerating nerve fibers. There is as yet no unequivocal proof for the inductive action of the lateral line nerve, and, as will be further shown in the discussion of the regeneration of sense organs, there is considerable evidence to the contrary for the amphibian. The possibility remains that there may be differences between fishes and amphibians in this respect. Such differences should be sought by further study of fishes.

MAINTENANCE AND REGENERATION OF LATERAL LINE SENSE ORGANS

It has been a popular theory that special sense organs (e.g., taste buds and lateral line organs) depend upon the trophic action of their specific nerve supply for maintenance of their structure and regeneration. This idea dates back to the work on mammalian taste buds by Ranvier (1875), Vintschgau and Hönigschmied (1876), Drasch (1887), Griffini (1887), Sandmeyer (1895), Meyer (1896), Boeke (1913, 1914), Olmsted (1921), Langworthy (1924), and Whiteside (1926), and has been more recently supported by Hayes and Elliot (1942). All these have agreed that the taste buds lose their structural integrity within a relatively short period after denervation. Vintschgau (1880), however, found that though most denervated taste organs disappeared, some remained for several months. And Baginsky (1893, 1894) found that some denervated taste buds persisted for at least 87 days.

Similar experiments on the taste buds of fishes (Olmsted, 1920a, 1920b; May, 1925; Torrey, 1934) indicated a dependent relationship between sense organ and nerve fiber and led to the postulation of a neurohumor responsible for such trophic action. Such a neurohumor has never been demonstrated experimentally. Evidence from transplantation experiments on urodele tongues does not support this theory (Stone, 1933b, 1940; Mintz and Stone, 1934). These experiments showed that the gustatory nerve is not necessary for the formation or maintenance of the structure of taste buds, at least for several months. The author has some data which verify and extend these experiments. More than a year after transplantation to the orbit, pieces of the tongue of *Triturus* still possess some taste buds (Wright, 1951).

Similarly conflicting evidence concerning the trophic action of the lateral line nerve exists. Parker and Paine (1934), Brockelbank (1925), and Bailey (1937) have supported the idea that the trophic action is of great importance in the catfish and believed that the sense organs disappear within a short time after denervation. Devillers (1948) grafted sensory epithelium of *Salmo fario* to parts of the body without lateral line nerves (interorbital space, or vitelline sac) and examined them 10 to 40 days after operation. He reported that the organs in young grafts degenerated, but that the organs were maintained in older grafts. He concluded that the nerves play a role which is indispensable for the development and maintenance of young organs, but that after that stage the integrity of the organ is not dependent on the nerve. Williams (1930) thought he had evidence in support of the immediate trophic importance of the nerve in Amphibia. This was based on the recognition of sense organs by the affinity of the sense cells for methylene blue used as a vital stain. Williams claimed that only a few days after denervation the sense cells failed to take up the stain. This was used as the criterion for organ degeneration. My own attempts to use this method have resulted only in a firm conviction regarding the capricious nature of the stain. I have found no consistency even in the reaction of normal organs to it. With the exception of Williams' work, all the evidence indicates that denervated lateral line organs of Amphibia can be maintained for long periods of time, though not indefinitely. There is no further evidence that they necessarily degenerate soon after denervation so far as the author is aware.

Harrison (1924) found no degeneration of denervated lateral line sense organs in young amphibian larvae during relatively short-term experiments. Likewise, Stone (1937) reported the persistence of amphibian sense organs after repeated nerve section, and Bedell (1939) noted no difference between the structure of denervated and normally innervated lateral line organs in 5 anuran tadpoles kept for 52 days. More recently, Speidel (1944a, 1944b, 9946a, 1946b, 1946c, 1947a, 1947b, 1947c, 1948, 1949) and Wright (1946, 1947) have presented the results of several approaches to the problem of the trophic action of the nerve, and

Speidel has made fine cinephotomicrographs in illustration of the essential features of his experiments. In the face of the conflicting reports of the past on this subject, it is satisfying that Speidel and Wright, independently using similar methods on different amphibian species, have obtained results in agreement. The following account of the effect of the trophic action of the lateral line nerve on the maintenance and regeneration of the sense organs is based on their work. (References will be given to detailed papers only.)

Lateral line organs can persist for many months following repeated nerve section. Using *Rana sylvatica*, *R. pipiens*, and *R. palustris* tadpoles, all hypophysectomized to preclude any effects of metamorphosis, and *R. clamitans* tadpoles which have an extended tadpole stage, Wright (1947) demonstrated by observations of the living organs in 67 cases that there is not an immediate degeneration of lateral line sense organs as a result of denervation. Observations on 1311 denervated organs in experiments having a duration from one week to 4½ months were reported. The sense organs remained throughout the short-term experiments, and some also were present at the conclusion of those experiments continued for 3 to 4½ months. Speidel (1948) carried similar experiments much farther (3 to 21 months) and clearly demonstrated that denervated lateral line sense organs of *Rana clamitans* tadpoles can persist for many months. He observed hundreds of denervated organs for more than 3 months. In 37 experimental animals, some organs persisted for more than 6 months, in one animal for 19 months, and in another for 21 months.

There is, however, a definite trophic action of the nerve demonstrated by these experiments. A normally innervated series of organs, or a reinnervated series, will increase in number by budding and fission during the normal growth of the animal. In denervated areas there is not a comparable increase in number. Denervated organs retain the ability to divide for months (as long as 10 months after denervation in one case reported by Speidel), but they do not do so to the same extent as normal organs. Moreover, in the long-term experiments a decrease in the number of organs in the denervated area was evident. Wright (1947) found unmistakeable evidence in those cases observed for 3 to 4½ months. In the 6 cases involved, 73 organs were reduced to 26 (a reduction of 65 per cent) whereas normally innervated organs in the same animals increased 29 per cent. Considerable variation was noted in the ability of denervated organs to persist: a few organs degenerated within a month; the vast majority remained longer. Speidel (1948) compared numbers of denervated, reinnervated, and normally innervated organs in 13 cases during the 2- to 5-month period after operation. He found a 26 per cent reduction in the number of denervated organs, a 34 per cent increase in reinnervated organs, and a 36 per cent increase in the normally innervated organs. [The difference between the 26 per cent reduction in denervated organs found by Speidel and that of 65 per cent found by Wright is probably not a serious discrepancy, since different species are involved (one hypophysectomized), and the environmental conditions maintained in the two experiments may have been quite different.] In a 10 month experimental animal Speidel found the following comparative data: 70 per cent reduction of denervated organs, 114 per cent increase in reinnervated organs, and 89 per cent increase in normally innervated organs. In more extended experiments a further reduction in number of denervated organs was noted: at 14 months, there was a 90 per cent decrease; and at 18 months there was a 96 per cent decrease.

The processes involved in the eventual disappearance of denervated sense organs have been described by Speidel (1948), and my own observations are in agreement. Atrophy is the first effect of denervation which may be seen, i.e., the organ becomes smaller but retains its normal morphological organization. Sometimes atrophy may be seen within a few weeks after denervation, but usually a few months elapse before it is noticeable. Organs may remain at this stage for months before further regression, or they may soon begin the next phase, that of dedifferentiation. In dedifferentiation some of the normal organization is altered. Loss of sense hairs is of common occurrence, and the normal radial arrangement of the component cells may be lost (Fig. 3). Partially dedifferentiated organs occasionally recover their organization, but unless reinnervated, the recovery is temporary. The third, and last phase is that of rapid degeneration, involving the death of the cells. The dead cells are probably removed by the macrophages in the region.

Cytological features of the sense cells of denervated lateral line organs follow the pattern of reaction of the organ as a whole. The atrophy of sensory

hairs, for example, is concurrent with atrophy of the sense cells and the entire organ. Before atrophy takes place, recovery after experimental injury to the hairs is similar in denervated and normally innervated organs (Speidel, 1949). Speidel has also studied the orange-colored granules found in the sense cells of freshly caught *Rana clamitans* tadpoles. These granules are extruded from the cells and are ingested by macrophages under the usual laboratory conditions. When the animals are replaced in a pond environment, the granules reappear. Denervation has no apparent effect on these processes.

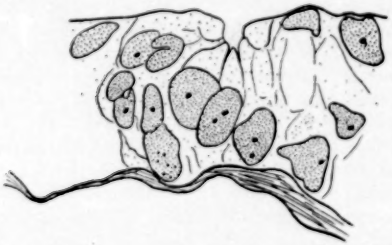

FIG. 3. CAMERA LUCIDA DRAWING FROM A HISTOLOGICAL SECTION OF AN ORGAN OF HYPOPHYSECTOMIZED RANA PIPIENS ON THE 91ST DAY AFTER DENERVATION
No hairs are apparent. The arrangement of supporting cells is no longer typical.

The pertinent conclusions from the work on Amphibia may now be listed: 1) Lateral line organs can persist for many months following repeated nerve section. 2) The normal increase in number of organs during the growth of the organism is inhibited after denervation. 3) In long-term experiments there is a decrease in the number of denervated organs through a regressive process involving atrophy, dedifferentiation, and total degeneration. 4) The cytological details of the sense cells are usually independent of nerve connections for several months, but eventually suffer the fate of the entire organ. These statements are offered in support of the theory that there is a definite trophic action of the lateral line nerve exerted upon the sense organs, but that the effect of its removal is not immediate. It is a long-range effect.

Further evidence to support the concept of the short-range independence of lateral line sense organs and to refute the idea that there is any inductive action of the lateral line nerve in the Amphibia is derived from experiments on regenerating lateral line organs. Such experiments have been performed on several species: *Pseudacris feriarum*, *Hyla crucifer*, *Rana clamitans*, and *Triturus viridescens* (Speidel, 1947a); *Rana pipiens*, *R. sylvatica*, *R. clamitans*, and hypophysectomized *R. pipiens*, *R. sylvatica*, and *R. palustris* (Wright, 1947). Stimulation of the midline of organs to regenerate may be effected by amputation of the tail tip. Within a few days a placode-like growth, derived from the remaining most distal organ, extends onto the regenerating tail region. These placodal cells form all organs on the new tail tip. No contribution of ordinary epithelial cells has been observed. The regenerating lateral line nerve normally accompanies the regenerating sense organs. In other words, the regenerative process is very similar to the developmental process. Experiments involving the denervation of the source organ before, simultaneously with, or after tail-tip amputation (and subsequent resection of the nerve to prevent reinnervation) have resulted in no effect on either the time or character of the regeneration of sense organs. Furthermore, Speidel (1947) has demonstrated that sense organs which have regenerated from denervated organs can give rise to placodal material for a second series of regenerate organs of apparently normal structure.

The lack of effect of nerve section on the regeneration of organs is reminiscent of the experiments mentioned previously (Harrison, 1903, 1924; Stone, 1931) which showed the relative independence of the ganglionic and migratory placodes in the development of the lateral line system. Further evidence may be recalled from the work of Stone (1937) in which tail tissue from a urodele larva, rotated 180°, was grafted in place of the tail tip of another larva in a number of cases. The budding process began very soon and proceeded rapidly, although, obviously, the original nerve connections had been severed.

In all of these experiments if there were a necessary induction of sense organs by the lateral line nerve, no sense organs should have developed. Since the facts are quite the contrary, it is clear that there is no inductive action demonstrated here. Also, if the trophic action of the nerve were an immediate necessity, no organs should have developed. Again the facts do not support this idea. It remains to be seen what the long-range effect of denervation is on the regeneration of the lateral line sense organs.

METAMORPHOSIS OF THE LATERAL LINE SYSTEM

In such urodeles as *Triturus viridescens*, which return to the water at sexual maturity, the sense organs do not completely degenerate at metamorphosis. Rather, as Dawson (1936) has shown they become covered by epidermal cells. Some of the sense organs, but not all, reappear at the surface when the animal again assumes an aquatic mode of existence. However, it is well known that the lateral line system of sense organs usually degenerates during the metamorphosis of anurans. Larsell (1925), in a description of the metamorphosis of the system in *Hyla regilla*, stated that the sense organs begin to disappear in tadpoles of 10–11 mm. tail length. The lateral line organs disappear rapidly on the whole animal, though some organs on the body and tail are still visible when the tail length is only 3.5 mm. By the stage of 1 mm. tail length, the sense organs are not visible.

Correlated alterations in the nervous system are not as obvious nor as well known. There have been a number of descriptions of the distribution of cranial nerves to the lateral line system of sense organs of amphibians since the classic work of Strong in 1895 (e.g., Coghill, 1906, 1916, *Triton* and *Ambystoma*; Norris, 1908, 1913, *Amphiuma* and *Siren*; and Göppert, 1928, 1929, *Salamandra* and *Necturus*). There have also been some attempts to analyze the metamorphic changes in the lateralis nervous system. Strong (1895) noted that the peripheral nerve fibers and the roots from the medulla concerned with the innervation of the lateral line system were lacking in adult anurans. Göppert (1928, 1929) described and figured the differences in cranial nerve distribution in larval and metamorphosed *Salamandra maculosa*. He stated that all the nerve fibers innervating the lateral line organs of the larva were lacking in the adult and that all nerve roots from the medulla running to the lateral line ganglia were also lacking. By study of serial sections and reconstructions made from them, he found that the lateral line ganglia disappeared completely by six weeks after metamorphosis. Wright (1946) was unable to find lateralis ganglion cells of the vagus in adults of *Rana palustris*, *Hyla versicolor*, and *Rana clamitans*.

Larsell (1920) described the myelinated lateral line roots of the facial ganglion which run to the auricular lobe and hence to the body of the cerebellum in several species of *Ambystoma*. In 1923, he described alterations in this pattern in anurans after metamorphosis (*Rana pipiens*, *R. catesbeiana*, *Hyla regilla*, and *Acris gryllus*). He found that the auricular lobes of the cerebellum were reduced, due to the lack of lateral line connections. Only vestibular connections remained. He published a more extensive paper (1925) on the cerebellum of *Hyla regilla* at different stages. He stated that the lateral line nerves underwent progressive degeneration from the 11 mm. tail stage on, and that just before metamorphosis was complete, at a 1 mm. tail-length stage, the lateral line tracts had completely disappeared. Larsell also examined the lateral line ganglia during the metamorphosis of *Hyla regilla* and found that they degenerated at the same time that the lateral line organs of the skin disappeared. Using a modification of the Nissl staining technique, he obtained evidence for chromatolytic degeneration of the lateralis ganglion cells of the facial, glossopharyngeal, and vagus ganglia. He stated that the number of degenerated lateralis ganglion cells in the tail length stages of 3.5 and 1 mm. exceeded the number found in the 12 mm. tail length stage. The natural interpretation was made that these changes reflect the transformation from a predominantly lateral line control to a spinal, vestibular, and optic control, in keeping with the habits of the metamorphosed animal compared with the tadpole.

Since lateral line organs degenerate during metamorphosis, it is pertinent to consider briefly what may cause the degeneration of tissues at that time. It has been known since the first thyroid feeding experiments (Guternatsch, 1912, 1914) that the thyroid is a causative agent in metamorphosis. These experiments were quickly followed by others which showed that hypophysectomy (Adler, 1914; Smith, 1916; Allen, 1916) and thyroidectomy (Allen, 1916) prevent anuran metamorphosis. Uhlenhuth (1917) demonstrated that there was some non-specific factor, which he called a "metamorphosis factor" that causes skin and eye pieces from a young *Ambystoma*, when transplanted to an older individual either of the same or of another species, to metamorphose at the time of the host's metamorphosis. The "metamorphosis factor" was, as he suspected, the thyroid. At the same time, Uhlenhuth showed, with reference to the type of spotting which developed on the skin at metamorphosis, that there was also

a factor contained in the skin. The "metamorphosis factor" was responsible for metamorphosis, but the other factor in the skin determined the nature of the metamorphic change.

That there are intrinsic factors within the tissues which determine their fate at metamorphosis has been amply demonstrated. For example, Schubert (1926) found that hind limb transplants on tadpole tails did not degenerate, and conversely, that tail skin placed on the back did disintegrate when the host metamorphosed. Schwind (1935) transplanted optic vesicle and some surrounding tissues to the tail bud in frog embryos and found that the eye differentiated, was maintained throughout metamorphosis, and went through characteristic metamorphic changes itself. When the tail was reabsorbed, the eye was located on the sacral region. But the nature of some of the changes taking place during metamorphosis is more complicated. There may be a series of related events, as shown by the experiments of Helff (1926a) in which the development of the opercular perforation was found to depend upon the atrophying gills underneath the operculum. Therefore, it is necessary to seek out all underlying causes for the variety of metamorphic changes which occur, involving all types of tissues.

Barfurth (1887) and Bataillon (1891) believed that the developing urostyle cuts off the blood supply to the anuran tail and that this causes the tail to atrophy. However, this may be discounted on the grounds of later work. Helff (1926b) ligated the aorta near the base of the tail and this failed to influence the atrophy of the tail, though the speed of blood flow was reduced 20 to 70 per cent. Later he (1928, 1930) removed the urostyle and found that the tail was resorbed. Therefore, a lack of blood supply due to urostyle formation cannot be the causative agent for tail atrophy. In the experiments of Schwind (1935), while the eye was on the tail, it was innervated by both afferent and efferent spinal nerves and blood was seen circulating in it. Therefore, neither the nervous connections nor circulation could be held responsible for tail atrophy, because, if so, the eye should also have degenerated. Brown (1946) has also presented evidence, from an histological analysis of the atrophying anuran tail, that the spinal nerves are not the causative agents in muscle atrophy.

The previously reviewed work on the trophic action of the lateral line nerve has a definite bearing upon the problem of metamorphic changes in the lateral line system. It was shown that the length of time necessary for the general degeneration of denervated sense organs is entirely out of proportion to the length of time involved in the metamorphic process. It takes too long between nerve section and organ degeneration for one to conceive that any degenerative change in the lateralis nervous system can be the causative agent for the normally occurring degeneration of sense organs at metamorphosis. The evidence reported by Brown (1946) supports this point of view. She found that tadpole tail nerves are highly resistant to breakdown during metamorphosis. She noted the absence of phagocytosis of the lateral line nerve and saw, in histological silver-stained preparations, lateral line nerves in tail stumps of less than 10 mm. length. Her general conclusion that nerve degeneration does not cause the atrophy of the tail during metamorphosis supports the conclusion drawn here that the degeneration of the lateral line nerve is not the causative agent in the breakdown of the lateral line sense organs during metamorphosis.

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POLYPLOIDY IN PTERIDOPHYTES

BY C. P. SWANSON

Johns Hopkins University

A review of PROBLEMS OF CYTOLOGY AND EVOLUTION IN THE PTERIDOPHYTA.

By I. Manton. Cambridge University Press, New York and London. $8.50. xii + 316 pp.; ill. 1950.

Stebbins' recent book, *Variation and Evolution in Plants*, has dealt primarily with evolutionary forces and tendencies operative in the seed plants, a group of relatively recent origin. The ferns and fern allies received but passing notice, although their phylogenetic ancestral position would suggest that a similar comprehensive treatment would be of much evolutionary value from a comparative point of view. Miss Manton's book, therefore, makes an excellent companion volume, since it considers in somewhat similar though less extensive fashion the evolutionary tendencies in the pteridophytes, and with comparisons drawn with a representativen angiosperm family, the Cruciferae. The similarity between the two books ends there, however. Whereas Stebbins' book is an excellent synthesis of existing knowledge, regardless of source, that by Miss Manton is essentially a monograph, being almost entirely the product and summary of her own researches, even to the comparisons made with the Cruciferae, a family which she has also investigated with notable success. A great portion of the data is published here for the first time, although it has been in the process of accumulation since 1932.

Miss Manton speaks of her book as "one of the more harmless consequences of the Second World War," a modest description indeed in view of the magnitude of the work, the significance of the findings in terms of plant evolution, and the general excellence of style and illustration. The experimental material includes 100 per cent of the known pteridophytes of the British Isles, and 98 per cent of that on the island of Madeira, together with all available species of the fern allies, the Psilotales, Lycopodiales, and Equisetales. The chromosome numbers of the species, hybrids, and distinct varieties have been established or confirmed, and an attempt has been made to evaluate the cytological data in each group in terms of the evolutionary trends in the ancient past and in more recent times. The conclusions, to be sure, are drawn from data obtained from a geographically restricted group of plants, but it is unlikely that their general validity for other pteridophytic flora can be so narrowly applied. Her findings can be briefly summarized as follows:

1). Hybridization is prevalent in both recent and ancient forms, the latter owing their species rank to stability arising from apogamous reproduction. As in the flowering plants, evolution has been reticulate as well as dichotomous.

2). Polyploidy is widespread, being found in over 50 per cent of the British forms, and in over 40 per cent of the more tropical Madeira species. The levels of polyploidy reached are far higher than those found in the flowering plants. In *Ophioglossum*, a primitive eusporangiate genus, diploid numbers of over 500 have been found, an odd fact when it is considered that in *Osmunda* sterility sets in at the tetraploid level. In the more ancient genera, such as *Equisetum*, *Tmesipteris*, and *Ophioglossum*, the degree of polyploidy can only be guessed at, the forms with lower chromosome numbers having disappeared. Very high polyploidy is therefore quite a primitive character, and it must be assumed to have had a high survival value in the pteridophytes, although attained and maintained at a sacrifice of evolutionary plasticity. This is indicated by a comparison of the conditions now existing in *Equisetum* and *Selaginella*, both equally ancient. The former has a haploid number of 108 chromosomes, and is made up of two dozen species scattered throughout the world;

Selaginella, a large genus of over 200 species, has a haploid number of 9. Polyploidy, per se, cannot therefore be considered a criterion of age, although very high levels may indicate great age. In the less ancient forms, polyploidy is equally rife, though of comparatively recent origin, a condition traceable perhaps to the climatic upheaval brought on by the ice age. Since a large portion of the leptosporangiate ferns are polyploid, the prediction is made that the Filicales are moving into a state of evolutionary stagnation and death as a result of their own cytological complexity.

3). As in the flowering plants, allopolyploidy superimposed upon hybridity can account for most of the increased chromosome numbers. Except for the experimentally induced tetraploid *Osmunda*, no authentic case of autopolyploidy has been found.

4). Aneuploidy is found among the pteridophytes, but with less frequency than polyploidy. The suggestion is made that this phenomenon has contributed more to the formation of generic and larger groupings than has polyploidy, which can only form species within the morphological limits of a given genus.

5). The last general conclusion is that the evolutionary potential of the pteridophytes is running down. The more rapidly evolving Polypodiaceae appear to be headed into the blind alley of high polyploidy that may permit survival but that will also prohibit further evolution. The forms with low chromosome numbers, such as *Selaginella*, *Isoetes*, and *Hymenophyllum*, are too specialized or stereotyped to undergo anything but microevolution to produce new species. In this regard Miss Manton would appear to disagree with those who consider microevolution to be but a step in the direction of macroevolution. Even *Osmunda*, primitive structurally and cytologically, has yielded, in its many years of cultivation, no mutant forms.

This book raises many more questions than it provides solutions, and in this respect it is both provocative and stimulating. It is, in final analysis, an exceptionally able piece of individual effort.

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

SCIENCE AND IMAGINATION IN SIR THOMAS BROWNE. *By Egon Stephen Merton. King's Crown Press, Columbia University, New York.* $2.50 (paper). x + 156 pp. 1949.

E. S. Merton starts his analysis of Sir Thomas Browne from the premise that "the circumference of Browne's being is represented by his science; the center, by his imagination," and his primary goal is to "inquire into the kind of influence Browne's science had on his imagination; we shall seek the center from the circumference."

The difficulty is, however, that Browne's science is of less import than the author imputes to it, and Sir Thomas probably took it less seriously than Merton implies. It hardly makes Thomas Browne a philosopher to label him an eclectic, nor an embryologist to point out that he toyed with "the doctrine of eggs." His science is peripheral, but he remained yet peripheral to it; his core was something else, and science never quite traversed the full radius. His interest in it was always extensive, while the true scientist's is sometimes intensive; and it is permissible to consider him charming, and still to question his depth.

In sum, Merton is not J. Livingston Lowes; Sir Thomas Browne is not Coleridge; and the Imagination remains unfathomable. While this is an interesting contribution among the many earned by Sir Thomas, the definitive analysis of the relationship of his science to his broader thought is yet to be written.

JANE OPPENHEIMER

PHILOSOPHY OF NATURE. *By Moritz Schlick. Philosophical Library, New York.* $3.00. xii + 136 pp. 1949.

The late Moritz Schlick was an outstanding member of that group of anti-metaphysical empiricist philosophers known as the Vienna Circle. It was the view of this group that all nonanalytic knowledge is based upon experience. In their eyes the task of philosophy was the analysis and reconstruction of the concepts of the natural sciences, and to this task they brought the fruitful and powerful techniques of Russell and Whitehead's mathematical logic. Among other things they

stressed the view that the sciences are ordered systems of statements, and they tried to construct criteria that would clearly distinguish between the statements of the sciences and those of other disciplines such as metaphysics, poetry, and ethics. *Philosophy of Nature* is not among the most perspicacious of Professor Schlick's writings. The essays in this book on such topics as Description and Explanation, The Construction of Theories, Causality in Classical Physics and in the New Physics, The Criteria of Life, and others, have the character of notebook jottings that might have been intended to serve as protocols for a later and more careful expansion. But they are all marked by the lack of pretentious folderol and the precision of statement that characterized Schlick's writings, and they might well serve as a kind of introduction to many of the methodological problems facing philosophers of science.

JOHN R. GREGG

THE BOND OF BEING. *An Essay on Analogy and Existence.*

By James F. Anderson. B. Herder Book Co., St. Louis and London. $4.00. xvi + 341 pp. 1949.

Plain men are beginning to suspect that metaphysicians such as Anderson discuss pseudo-problems and enunciate statements that either are analytic (trivially true because of their linguistic form, like "All sick crocodiles are sick") or else are nonsensical (like "Glycolysis has the texture of velvet"). Failure to distinguish analytic sentences from those that assert something about the world leads Anderson, for example, to assert in the spirit of imparting some profound truth about the universe that "... all efficient causes agree in that they produce effects; all effects in that they are produced ..." But surely this is utterly trivial, for if efficient causes are events that produce effects, and if effects are produced events, then his assertion is logically equivalent simply to the proposition that all events that produce effects produce effects and all produced events are produced. Another instance of this failure leads Anderson to share the metaphysical belief that existing is an *act* that, like swimming, things engage in. For him, therefore, there is the problem of clarifying the nature of the activity denoted by the intransitive verb "exists." Now both Anderson and the zoologists would like to claim that all whales swim; namely, that everything that is a whale swims. And it is worth noting that even were they to deny it and make the counter-claim that there exists something that is a whale but that does *not* swim, they would not be self-contradictory but only mistaken. Furthermore, they both would claim that whales exist. But by the latter they would mean different things. *Zoologists* would mean simply that there are whales—a claim that is neither trivial nor nonsensical, and whose denial, again, is not self-contradictory but simply false. But *Mr. Anderson*, using "exist" as a verb like "swims," would presumably mean that everything that is a whale exists —a claim that is either analytic (or nonsensical), for *its* denial entails the self-contradictory (or nonsensical) proposition that there exists something that is a whale but that does not exist. "Exist" simply refuses to behave properly as a word that (like "swims") denotes an activity. But with its abandonment as an activity-word there disappears the pseudo-problem of explaining the nature of any act allegedly denoted by it. Perhaps Anderson gives the metaphysical game away when he says that "Metaphysical language almost never 'says' what it means. That is why it is such a fruitful source of error and illusion."

JOHN R. GREGG

BIOLOGY: *The Human Approach.*

By Claude A. Villee. W. B. Saunders Co., Philadelphia & London. $5.00. xvi + 580 pp.; ill. 1950.

As its title implies, this book should be considered among those textbooks that have been written with a view toward making biology a more appealing and useful subject to the general student. Thus it is that the table of contents shows a heavy emphasis upon human physiology (over 40 per cent of the subject matter) and other topics that are among those generally held to treat with basic biological principles.

Correspondingly, discussion of the variety of plants and animals has been greatly restricted. (Many botanists will be disappointed to note the perpetuation of the classical four-phylum system of plant classification.) Additional sections include an introductory part concerned with the physico-chemical background of life, protoplasm, cells, and tissues; a part on microorganisms and infectious diseases; and one on the reproductive process. The format of the book is attractive, its illustrations are numerous and good, and much information of potential interest to the elementary student is covered in its various sections. However, while the choice of material for this book would seem to be a good one, as revealed by the table of contents, the reviewer cannot recommend it because of certain reservations.

The first of these is my own belief that the weighting of a textbook in favor of human physiology and "biological principles" is not sufficient justification for considering it a human approach to biology. Rather, I believe that, in addition to such weighting, care must be taken to bring out man's relations to the living world and the inanimate universe in a lively, well integrated, and interesting manner. When judged on this basis, the present textbook appears to the reviewer to be somewhat dull and not as likely to catch the interest of students as its table of contents might indicate.

The second reservation rests upon the discovery of minor statements concerning various subjects familiar to the reviewer, that are made in such a manner as to detract from the forcefulness of the book. Examples of these are to be seen in the comments that nitrogen-fixing bacteria "live in the soil at the roots of leguminous plants," and that anaerobic bacteria "are able to obtain their oxygen supply by breaking down organic compounds which contain it" (p. 387). A similar remark is made to the effect that alcaptonuria "is inherited through a single pair of recessive genes" (p. 450); and another, that "still another eugenic method, which operates almost everywhere, is the prohibition of the marriage of brothers and sisters or first cousins" (p. 461). A final example can be made of the discussion of the origin of flounders through preadaptive mutation (p. 473). This discussion implies that flounders originated suddenly from a mutation that gave rise to a fish with both eyes on the same side of its head and which took at once to "grubbing in the mud for food"!

A final reservation rests upon the point that the text is not concerned with the problem of the conservation of natural resources, a serious omission, in the reviewer's opinion, when a human approach to biology is made.

As a last word, it may be noted that many botanists and geneticists will regret the fact that no reference is made, in the discussion of the phenomenon of the alternation of generations in plants, to the chromosome numbers at various stages in the life cycles.

JOHN CUSHING

VARIABILITY IN RECOGNIZING SCIENTIFIC INQUIRY. *An Analysis of High School Science Textbooks. Teachers Coll., Columbia Univ. Cont. Educ., No. 955.*

By Richard H. Lampkin. Bureau of Publications, Teachers College, Columbia University, New York. $2.10. xii + 79 pp. 1949.

This is a report on an attempt to analyze high school science textbooks, in order to see to what extent the authors express an aim to condition students in the scientific method and attitude, and to what degree such expressed aims are carried through in the texts themselves. Twelve science texts, 3 in each field (general science, biology, physics, and chemistry), were studied by 12 readers, who bracketed and coded certain types of passages in the "composite text" made by dismembering each text and then reassembling the "composite text."

The results of these analyses are reported, but the author stresses the point that variability among readers and their particular "biases" greatly reduces the reliability of the findings. They were able to say definitely that an average of 10 per cent per book was bracketed by the 12 readers as being devoted to scientific inquiry, and that there is wide variation in texts in the same field and in the three fields studied with regard to the emphasis placed on scientific inquiry, as judged by the readers.

The Appendix includes: References Cited, Elements of Scientific Inquiry, Instructions for Analysis of Composite Textbooks, Criteria for Selecting Passages, and Specimen Fragment-Analyzed and Coded. The book should interest the makers of textbooks, as well as high-school science teachers.

ELLA THEA SMITH

GENERAL BIOLOGY *for Colleges. Second Edition. The Century Biological Series.*

By Gairdner B. Moment. Appleton-Century-Crofts, New York. $5.00. xvi + 680 pp.; ill. 1950.

The second edition of this widely-used text has been considerably reinforced with much factual information which has come to light since the original edition was published in 1942. The most significant additions are in the areas of genetics, cellular physiology, animal psychology, and ecology. The illustrations have been considerably altered and improved.

EVOLUTION AND THE FOUNDERS OF PRAGMATISM.

By Philip P. Wiener; with a Foreword by John Dewey Harvard University Press, Cambridge. $5.00. xvi + 288 pp. 1949.

In the history of ideas, the influence of Darwinism upon American thought makes one of the most interesting and, to biologists and philosophers alike, one of the most important chapters. Richard Hofstadter's valuable book, *Social Darwinism in American Thought*, has covered a particularly significant aspect of the subject. Now Philip Wiener adds a series of brilliant and scholarly studies, somewhat related because they concern the origin of American pragmatism, but much more closely bound because of the personal friendship and mutual influences within the informal Metaphysical Club that formed at Harvard in the 1870's. It was indeed an original group—Chauncey Wright, Charles S. Peirce, William James, John Fiske, Nicholas St. John Green, and Oliver Wendell Holmes, Jr. The titles of the chapters characterize very well their distinctive roles in the birth of pragmatism and the impregnating atmosphere of evolutionary thought that was so necessary to it: Chauncey Wright, Defender of Darwin and Precursor of Pragmatism; The Evolutionism and Pragmaticism of Peirce; Darwinism in James's Psychology and Pragmatism; Social Evolutionism: Fiske's Philosophy of History; The Pragmatic Legal Philosophy of Nicholas St. John Green; Evolutionary Pragmatism in Holmes's Theory of the Law; The Philosophical

Legacy of the Founders of Pragmatism. All of these essays will be essential to the student of American philosophy. The essays on Green and Holmes will particularly appeal to the student of law, government, and political philosophy. The chapter on Fiske is important to the historian and the biologist, although the author seems less sympathetic to Fiske than to his other characters. Modern biologists who believe themselves original in conceiving of society as an organism, or in emphasizing the prime importance of "brotherly love" and cooperation in human evolution and historical progress alike, would do well to refer to the part taken by Fiske in the early years of the great Darwinian debate. The chapter on William James is another that will profoundly interest biologists, and of course psychologists, but it is a more familiar story than the accounts of Chauncey Wright and Charles Sanders Peirce. These are paramount in interest and importance for every American scientist. In Wright's defense of Darwinism we find the roots of our concepts of the "neutrality" of science toward metaphysical, theological, and ethical opinion, and of philosophy as a "pluralistic scientific methodology." Peirce, on the other hand, regarded science as a social enterprise, and evolution as "a generalized theorem of probability." It was Wright who most clearly and plainly arrived at the conclusion that "ideas are beliefs on which a man is prepared to act, and thus have an evolutionary survival value" (Wiener). This is the real root and genesis of pragmatism.

There is nothing facile about this book. It is solid stuff, not light reading. Yet, to quote the author again, "there is scarcely any basic problem in the natural and social sciences to which this group did not make some important contribution to our thinking." No biologist should be guilty of neglecting such a book. It elucidates our heritage of evolutionary ideas.

BENTLEY GLASS

THE BRITISH JOURNAL FOR THE PHILOSOPHY OF SCIENCE. *Vol. I, No. 1.*

General Editor: A. C. Crombie. Editorial Board: J. R. Baker, J. D. Bernal, H. Dingle, E. A. Milne, M. Polyanyi, K. R. Popper, Earl Russell, E. Schrödinger, Sir Charles Sherrington, Charles Singer, Sir Edmund Whittaker, and J. H. Woodger. Thomas Nelson & Sons, Edinburgh and London. Published quarterly. Annual subscription 22s. to members of The Philosophy of Science Group, 30s. to non-members, post free; single issues 7s. 6d., postage 2d. No. 1: 76 pp. May, 1950.

All biologists who are interested in the philosophy of their science will find this new journal worthy of attention. Contents of the first issue: A Theory of Measurement (H. Dingle); Critical Epochs in the Development of the Theory of Science (E. W. Beth); Descartes and the Body-Mind Problem in Physiology (M. H. Pirenne); and Metaphysical Interpretations of Science, Part I (Philipp Frank). Book reviews of selected works important in this field are included in each number. Other biological contributions in the first volume, now completed, are The 'Drive' Element in Life (E. S. Russell); An Outline of General System Theory (L. von Bertalanffy); and Causation and Explanation in Theoretical Biology (J. S. Wilkie).

BIOLOGY: HISTORY AND BIOGRAPHY

SOME EARLY TOOLS OF AMERICAN SCIENCE. *An Account of the Early Scientific Instruments and Mineralogical and Biological Collections in Harvard University. By I. Bernard Cohen; with a foreword by Samuel Eliot Morison. Harvard University Press, Cambridge Mass.* $4.75. xxi + 201 pp. + 46 plates. 1950.

The occasion for this book was an exhibit at Harvard University in 1949 of scientific instruments of historic significance. All of them were over 100 years old, but none antedate 1764, the year of the great fire that destroyed practically the entire scientific equipment of the university. In this case the phoenix arose again from its own pyre. The only instrument to escape destruction was a telescope which at the time happened to be in the home of Professor John Winthrop. This instrument was not available for display, however, as it is now the property of the Science Museum at South Kensington in London, which furnished a photograph of it for reproduction in this volume. On the barrel is engraved the statement that it was presented to Harvard by "The Honble. Tho. Hancock, Esq." It was used by Professor Winthrop and taken by him to Newfoundland to observe the transit of Venus in 1761. According to the author, this was the first American scientific expedition to be sponsored by a college. This was not, however, the first telescope to be owned by Harvard. As early as 1672 a telescope had been presented to the University by another John Winthrop, presumably an ancestor of the professor. This instrument was lost in the conflagration. It was the first scientific instrument to be owned by Harvard, but was followed by others so that at the beginning of the 19th century this scientific equipment compared favorably with that of most European colleges.

For the proper appreciation of these scientific instruments it is necessary to know something of the history of science as taught at Harvard. Thus what was intended to be a guide-book to an historical collection became an historical treatise. The author tells us how Professor Winthrop, while demonstrating a balance to his classes, stated that unless the weights in the pans were inversely proportional to their distances from the fulcrum, the balance could not "equiponderate."

Could such a word have been used or understood anywhere except at Harvard?

The successor to Winthrop was Samuel Williams, who continued the tradition by leading another Harvard expedition to observe an eclipse of the sun in 1780. Interest attaches to this expedition because the Revolutionary War was then going on, and though the path of eclipse lay beyond the British lines, the British allowed him to go freely where he wished to make his observations. Can anyone imagine a modern government so conscious of the importance of science that it would be willing to extend such a courtesy to an enemy? Another activity of Professor Williams was the publication during the same year of the account of "a very uncommon Darkness in the State of New England." This was the event which certain contemporary fundamentalist churches untilize in explaining a prophetic passage in the apocalypse.

The part played by Harvard University in the scientific development of this country tends to be overlooked by historians, owing to the fact that certain of them, notably John Fiske, have emphasized such subjects as law and theology, the teaching of which certainly preceded that of science. But the large number of instruments for scientific purposes dating from the eighteenth century and still in the possession of Harvard bears witness that the teaching of science was not neglected. Certainly Harvard College took the lead in promoting scientific research among the colleges of the United States, and it exercised an influence in New England comparable to that of the American Philosophical Society in the other colonies. The author has done a scholarly piece of work in assembling the 45 original plates which illustrate some of these instruments, as well as numerous other plates from earlier sources, photostats of original documents, and detailed descriptions quoted from them. While he has disclaimed any attempt to write a history, he has laid a foundation upon which future historians of the development of the sciences in America may build. I believe, in fact, that he has already written a great part of such a history.

THE CENTENNIAL OF THE SHEFFIELD SCIENTIFIC SCHOOL.

Edited by George A. Baitsell. Yale University Press, New Haven. $3.00. xiv + 206 pp.; ill. 1950.

The Sheffield Scientific School of Yale University celebrated its centennial in 1947 by inviting four outstanding scientists to deliver Silliman lectures in physics, chemistry, virology, and genetics. These lectures, given respectively by O. E. Lawrence, Linus Pauling, W. M. Stanley, and G. W. Beadle, have been incorporated into this celebration volume by G. A. Baitsell. In each lecture, the general theme was the "progress and promise in the sciences." In addition, the volume also contains the citations for honorary degrees (E. W. Sinnott), as well as other addresses on Benjamin Silliman and the Sheffield Scientific School by C. H. Warren, E. W. Sinnott, J. F. Fulton, H. B. Vickery, and G. A. Baitsell. It is a fitting memorial to the man and the school for whose founding and early development he was so largely responsible.

LIFELONG BOYHOOD. *Recollections of a Naturalist Afield.*

By Loye Miller. University of California Press, Berkeley and Los Angeles. $2.75. x + 226 pp.; ill. 1950.

A student of nature in this book traces his growth in California to the development of his interest in the biological and paleontological fields. His presence at the time of the fossil discoveries in La Brea tarpits 40 years ago closes the first part of the book with exciting adventure. Part Two is devoted to early explorations in Arizona, Baja California, Oregon, and Panama. His enthusiasm for all he saw shows his closeness to the living things about him. The last part of the book, save for an epilogue, contains selected writings on birds. Miller "did not love men less because of his friends in nature," but "more because of a ripening of the spirit." So many scattered worthwhile references to scientific material are included that it is a pity the book lacks an index. The enthusiasm of this naturalist is contagious and pleasant.

LORUS J. & MARGERY J. MILNE

ECOLOGY AND NATURAL HISTORY

THE SEA AND ITS MYSTERIES. *An Introduction to the Science of the Sea.*

By John S. Colman. G. Bell and Sons, London; W. W. Norton & Co., New York. 12s. 6d.; $3.75. 261 pp. + 16 pl. and map; text ill. 1950.

By mysteries the author does not mean the strange creatures of the deep which have been the subject matter of at least half a dozen books entitled *The Sea and Its Wonders*, but the critical and still incompletely understood aspects of marine biology and oceanography, such as the problem of plankton indicators, coral reefs (with a strong Darwinian bias), the navigation of *Physalia*, and the zonation of littorines. It is inevitable that a book of this type should include a great deal of standard material, but a surprising amount of rather recent information has been culled from the literature and the author's own experience to make a fresh and up-to-date summary of our knowledge of the sea. As an introduction for laymen it is excellent, and it should also be a good refresher for oceanographers who are in growing danger of becoming lost in their

particular specialized division of this vast science. The illustrations on the whole are good, but the photographs of groups of plankton organisms cannot mean much to an uninitiated reader, since they appear as whitish shapes on a black field. There is a well selected short reading list and a comprehensive index.

JOEL W. HEDGPETH

STRANGE SEA LIFE.

By Gladys Vondy Robertson and Vera Graham; illustrated by Michael Bevans. Henry Holt & Co., New York. $2.50. xii + 115 pp.; ill. 1950.

This little book, illustrated with black and white drawings which are more artistic than accurate, is intended for young children; but its rather choppy treatment of subject matter is more apt to arouse questions than to forestall them. There are some unfortunate mistakes, such as the ascription of glochidia to marine bivalves, free release of eggs by barnacles, the shell of the argonaut, and the description of oyster larvae as "small, black, oval shaped young with whiplike tails," to mention a few. However, the principal faults of this book are not such slips, but its static, dry-land approach (the peculiar, spotty information about the occurrence of certain animals indicates that the authors have done most of their beachcombing in the library), along with the conventional, familiar attitudes of the illustrations. A children's book, at least in my opinion, deserves the most accurate and meticulous illustrations possible to withstand the scrutiny of childhood's long hours, or it will soon be cast aside and forgotten.

JOEL W. HEDGPETH

PLANT ECOLOGY WORK BOOK. *Laboratory, Field and Reference Manual.*

By J. T. Curtis. Burgess Publishing Co., Minneapolis. $1.75 (paper). ii + 39 pp. + 64 hardwood forest data sheets; ill. 1950.

The author of this manual has contributed a growing series of significant papers to the field of plant ecology, and his studies in the field have been a factor in developing highly successful courses at the University of Wisconsin. Thus the manual reflects to some extent the research contributions of the author. Yet it is primarily a publication designed for an introductory course in plant ecology, in which an effort has been made to strike a balance between autoecological and synecological material. However, the major emphasis lies on the field work, where analyses of the species composition of plant communities native to Wisconsin play an important part. Maps of the climate, soils, and vegetation of Wisconsin are accompanied by vegetational maps for the region and for the entire United States. Species lists of plants occurring in the principal associations of Wisconsin are given with both scientific and common names. In addition, carefully selected references to the literature are included, in order to add to the usefulness of the manual. The text, citations, and species lists have been prepared with care, so that there is a notable absence of typographical or other errors. The manual, in its present form, will not likely be used successfully outside of the North Central states, because of the regional nature of the plant communities studies. With modifications of species lists, to conform to vegetational variation in the deciduous forest region, it could be adapted for considerably wider use.

WILLIAM B. DREW

MYCOTROPHY IN PLANTS. *Lectures on the Biology of Mycorrhizae and Related Structures.*

By Arthur P. Kelley. Chronica Botanica Co., Waltham, Mass.; Stechert-Hafner, New York. $4.50. xvi + 223 pp. + 5 plates; text ill. 1950.

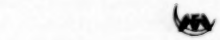
This volume attempts to summarize the present status of knowledge concerning mycorrhizae, and the complex relationships between many higher plants and the fungi with which they are associated in nature. That a need has existed for a book of this type is apparent when it is recalled that Rayner's monograph, *Mycorrhiza*, appeared 24 years ago. The present book with an historical acount, after which there follows a survey of the occurrence of mycorrhizae among the various groups of plants, those of the liverworts, certain ferns, the conifers, orchids, heaths, and various forest trees having been most studied. The nature of the fungus component is then considered: all of the major classes of fungi are represented, with certain phycomycetes, agarics, and imperfect fungi being most common. Evidence from paleobotany is summarized to indicate that the mycorrhizal association is an ancient one.

Consideration is given to the geographic distribution of mycorrhizal plants, and to an analysis of the factors in soils which promote or retard mycorrhizal development. Two succeeding chapters summarize knowledge concerning the so-called mycothalli of liverworts, lycopods, and ferns, the mycorrhizomes of pteridophytes, the fungus-induced nodules of alder and other plants. The structure of mycorrhizal and non-mycorrhizal roots, and of ectotrophic and endotrophic types is considered. The obligate nature of the mycorrhizal association for many plants is discussed with reference to the particular groups of plants involved. The numerous theories as to the roles of the fungus and higher plant components of the mycorrhizal association, concerning which much additional work remains to be done, are dealt with. Björkman's hypothesis concerning the relation of mycorrhizal formation to

conditions favoring carbohydrate excess in the host plant is rather inadequately treated.

The format of the book is attractive, in keeping with that of others in the series of plant science books by this publisher, and the material in the present volume is well documented.

F. T. WOLF



ANIMAL BABIES.

By Margaret Jean Bauer; illustrated by Jacob Bates Abbott. M. A. Donohue & Co., Chicago and New York. $2.00. 88 pp.; ill. 1949.

Like other volumes in the Chicago Natural History Museum series of natural history books for children, *Animal Babies* is beautifully written, and has been excellently illustrated by Jacob Abbott. Its subject matter ranges from chipmunks to elephants, from koala bears to whales, and is handled accurately but simply, and with a fine sense of proportion and humor. It is to be hoped that a similar series dealing with plant life may come from the pens of the botanical staff-members of the museum.

OUR DESERT NEIGHBORS.

By Edmund C. Jaeger. Stanford University Press, Stanford, California; Geoffrey Cumberlege, Oxford University Press, London. $5.00. x + 239 pp. + 15 plates; text ill. 1950.

For one who has been exposed to the deserts of the Southwest, it is like renewing old friends to read this book, but for those unable to travel this is a delightful way to meet pocket gophers, coyotes, pack rats, and scorpions. From long experience in the field, E. C. Jaeger has written about "our desert neighbors" in an intimate and personal way. When he refers to the California roadrunner as "Old Roady," you are charmed into following his pranks, "sportive nature," and queer eating habits. "This strange cousin of the cuckoo has earned his name from his apparent delight in sprinting along roadways," and he is called "ground cuckoo because of his inability to leave the ground in long-sustained flight." Even the lesser desert creatures are not neglected. The account of the scorpion is very friendly. You cannot help admiring "Old Scorpio" and learning something from his homing instincts. The book is attractive, the cloth binding bearing designs of the desert denizens. The end papers illustrate the distribution of the North American deserts in order to provide the background for the animals discussed. The excellent pen and ink drawings by Mr. Gish enhance the book. There are as well numerous borrowed photographs used for illustrations. There is a list of selected references and an index to this very worthwhile writing.

LORUS J. & MARGERY J. MILNE

LET'S GO TO THE DESERT.

By Harriet E. Huntington. Junior Books, Doubleday & Co., Garden City, N. Y. $2.50. vi + 90 pp.; ill. 1949.

A children's book based on a series of photographs of desert plants and animals faced by simple descriptions of the organisms figured. The pictures are excellent, but reproduced in a manner somewhat dull and disappointing. As the prose is not outstanding, being a little on the "Oh goody" side, the reviewer cannot recommend the book wholeheartedly.

JOHN CUSHING

WILD ANIMALS OF THE SOUTHWEST.

By George Cory Franklin; illustrated by L. D. Cram. Houghton Mifflin Co., Boston; Riverside Press, Cambridge. $2.50. 214 pp.; ill. 1950.

Following in the tradition of E. T. Seton, the author portrays the country of our southwest and its larger animals through a series of chapters, each devoted to a particular animal. Each is convincingly done, and the young reader is given a well-rounded group of animal stories guaranteed to hold his attention.

BEGINNER'S GUIDE TO FRESH-WATER LIFE.

By Leon A. Hausman. G. P. Putnam's Sons, New York. $2.00. 128 pp.; ill. 1950.

This little book is an interesting addition to the *Beginner's Guide Series* of Putnam's. It contains over 250 illustrations and descriptions of the most common animals found in fresh water, as well as a list of helpful books and a good index. It should be useful not only to the amateur working on his own, but also to those high-school biology students who develop a special interest in fresh-water life.

ELLA THEA SMITH

FISHING IS FUN.

By Arthur H. Carhart. Macmillan Co., New York. $1.95. 122 pp.; ill. 1950.

FISHING IN THE WEST.

By Arthur H. Carhart. Macmillan Co., New York. $4.00. x + 144 pp. + 24 plates. 1950.

The contrast between this first title, *Fishing is Fun*, and the title of Tyndall's book on the sport of mountain climbing, *Hours of Exercise in the Alps*, demands comment. Can it be that by the mid-twentieth century we have reached the opposite pole from where Tyndall stood in the mid-nineteenth? Then it seemed necessary to be reminded that a sport was not mere fun but also served a serious purpose. We, it would appear, must be reminded that sports *are* fun.

The first of Arthur Carhart's two enjoyable volumes is ideally suited to the novice. Here he will find in non-technical language all he needs to know about tackle and bait, and about how and when and where to use them. The biologist will note the brief but competent chapter on how to identify common fish, illustrated by pen and ink sketches after the manner of Roger Tory Peterson. The final chapter on conservation is full of sound sense.

The second book, on fishing in the Rockies and points west, is fast reading entertainment, chiefly about various kinds of trout. It is distinguished by an abundance of really superb photographs. The chapter on conservation at the end of this volume attacks the "grandiose" big dam programs of the Federal Bureau of Reclamation so vigorously that the reader almost comes to feel that it must have been dictated, if not written, by the fish.

GAIRDNER B. MOMENT

WESTERN LAND AND WATER USE.

By Mont H. Saunderson. University of Oklahoma Press, Norman, Oklahoma. $3.75. xii + 217 pp. + 8 plates. 1950.

The title of the book first needs a word of explanation —"western" here refers to what lies beyond the 100th meridian, although Saunderson takes times for a pungent word on what is happening to the much abused soil of Iowa.

It is immensely satisfying, when reading on a controversial topic, to discover that an author is not only honest and unafraid, but thoroughly well informed—in this instance on very complex matters of natural history and human behavior. Far too many discussions of critical land-use problems have been muddied, not alone by self-interest and trimming, but by half-knowledge and even ignorance. *Western Land and Water Use* is not like that.

Saunderson starts by showing that we are likely to need all the production we can get within our nation's boundaries as time goes on. He then documents his belief that the West faces general and major trouble with respect to its resources. The remainder of his book considers how this somber and costly prospect can be dealt with.

Noting first the tentative, fumbling character of our national land policy, the author proceeds to discuss public lands which comprise over half the area of the western states, livestock grazing, reclamation, forestry, and water control. In his concluding chapters he urges no doctrinaire solution of any of these problems, but his insistence on the difficulties ahead and in the need for study and intelligent caution is worth far more than any ready-made answers that have been offered to date.

PAUL B. SEARS

THE ECOLOGY OF ANIMALS. *Third Edition. Methuen's Monographs on Biological Subjects.*

By Charles Elton. John Wiley & Sons, New York; Methuen & Co., London. $1.25. x + 97 pp. 1950.

A reprint of a little classic. American purchasers need to be warned that "third edition" means, in our usage, no more than "third reprinting." Even though not revised since its original issue in 1933, the little work is so valuable an introduction to ecology that it is a welcome addition to the Wiley series.

EVOLUTION

MENDELISM AND EVOLUTION. *Fifth Edition. Methuen's Monographs on Biological Subjects.*

By E. B. Ford. John Wiley & Sons, New York; Methuen & Co., London. $1.25. xii + 122 pp. 1949.

A reprint of the Fourth Edition, revised in 1945. This is an invaluable introduction to the genetic aspects of evolution.

GENETICS AND CYTOLOGY

EVOLUTION.

By Chapman Pincher. Herbert Jenkins, London. 7s. 6d. net. 199 pp.; ill. 1950.

The objectives of this book are to present the core of the evidence for organic evolution and to give an account of the current explanation of evolution. The book is intended for the general reader and proceeds by the question-and-answer method. Experts in a given field (anatomy, paleontology, genetics, etc.) may feel that their discipline has been neglected, but the total effect of the book is considerable.

The book is in three sections. The first, on The Course of Evolution, briefly but adequately recounts evidence for evolution. The second, on Inheritance and Variation, explains concepts of the nature of inheritance. The third section, on Evolution in Action, is a synthesis of the first two.

This volume may be highly recommended for the average scientific reader and for the expert who wants a brief review of evidence in related fields bearing on the facts and interpretation of organic evolution.

EARL L. GREEN

FINDING THE MISSING LINK.

By R. Broom. Watts & Co., London. 6s. vi + 104 pp. + 1 pl.; text ill. 1950.

Not at all a large book, *Finding the Missing Link* would be still smaller if it were rid of all its acrimony against those who have ventured to differ with its author, of

all its loose digression and teleological speculation, and above all of its unbridled extrapolations from fact into the realm of fancy. Such a book makes it no easier to see in proper perspective the magnificent discoveries by Broom and Dart of so unprecedented a wealth of fossil primate material. There is no question whatever about the extraordinary importance of the australopithecine finds. On the other hand, this book, with its rough sketches of reconstructed "ape-men," its long passages of letters and quotations from supporters of Broom's views, and its appeal to an "élan vital" as the secret of evolution, is best regarded as a record of the discoveries and a memorial to the unique qualities of its author's temperament. What can be said about the statement that "the factors or causes of evolution are very rarely discussed at scientific meetings . . ." or the quoted remarks of noted evolutionists, made from 1925 to 1929, that express views about which they have long since changed their minds?

It is best to forget these strictures and to revert to the discoveries themselves. Broom has shown astounding energy and pertinacity, in spite of severe hindrances and difficulties, in unearthing material related to human origins that is quite unsurpassed in extent and significance. Virtually singlehanded, with rare genius for locating important finds, he has amassed fossils which it may take a century to study fully and evaluate properly. One notes with sadness the recent announcement of his death.

BENTLEY GLASS

CELL GROWTH AND CELL FUNCTION. *A Cytochemical Study.*

By Torbjoern O. Caspersson. W. W. Norton & Co., New York. $5.00. 185 pp.; ill. 1950.

This book, comprising the Salmon lectures, is the first summary of cell spectroscopy to appear by the author in English. It serves as an excellent introduction for a reader who desires to review the entire field of spectroscopic technique as well as to interpret such ultraviolet absorption studies. Since essentially all the work done in this field has come from Caspersson's laboratory, the author's authority is great.

The presentation of the subject matter is very much along the lines by which the field developed chronologically. First, there is a detailed consideration of the problem of image definition and of measuring absorption in extremely small volumes. Later, there is a detailed analysis of the optical problems which must be resolved if one is to measure such absorption over distances comparable to the wave-length of the light used, and finally, a detailed account of the apparatus at present used in Stockholm for microabsorption measurements. Since the apparatus is so complex that it is probable that there will be few laboratories able to construct it, one is reassured to see how carefully the author has analyzed the optical problems, and taken into consideration such limitations as exist in the interpretation of results. There is one point, however, which seems to have escaped detailed consideration, although it would seem of some importance in many measurements. This is the problem of the degree to which chemical changes produced by absorbed ultraviolet radiation may affect the measurement of absorption in very small volumes. The author gives 10^{-12} mg. as a figure for the lower limit of his measurements. This is 10^{-15} g., and for a molecular weight of 10^6 amounts to the measurement of only a few hundred molecules.

The rest of the book covers the results obtained on a great variety of cells and tissues. The methods used to resolve mixed absorption curves into protein, ribose nucleic acid, and desoxyribose nucleic acid fractions are presented well, and the reader will find an excellent collection of ultraviolet photomicrographs to illustrate the various points in the cell at which absorption is measured.

L. J. MULLINS

THE CYTOLOGY AND LIFE-HISTORY OF BACTERIA.

By K. A. Bisset. Williams & Wilkins Co., Baltimore. $3.50. xii + 136 pp.; ill. 1950.

Following initial chapters on staining techniques and cell structure, the author presents, as he expresses it, "a reasoned case for regarding bacteria as living cells with the same structure and functions as other living cells." The references are restricted to the more recent publications, and much of the information is based upon the author's personal researches. Most cytologists would agree that the bacteria contain a nucleus-like body, and that, if Lederberg's data are correctly interpreted, linear order of the genes, gene segregation, and sexual fusion differ but little from that already established in higher forms. Although the latter phenomena have been found only in the K-12 strain of *E. coli*, the author concludes that the cytological evidence bearing on chromosome structure and segregation, and on bacterial sexuality is confirmed by the genetical evidence. The argument is also extended to explain conjugation, dissociation, and the evolution of the bacteria, much as for higher forms. The evidence and the arguments presented are stimulating and indicative of careful study, but it is unlikely that the majority of cytologists and bacteriologists will share the author's confidence in the conclusions which have been drawn.

C. P. SWANSON

BIOCHEMICAL ASPECTS OF GENETICS. *Biochemical Society Symposia No. 4.*

Organized and Edited by R. T. Williams. Cambridge University Press, New York and London. $1.50 (paper). 60 pp. 1950.

Although some of these reviews have already been superseded by more recent work published elsewhere, the collection as a whole serves to give a concise and well-rounded review of biochemical genetics today.

In the Introduction, J. B. S. Haldane has committed himself strongly to a modified "one gene–one enzyme" hypothesis in the words: "Roughly speaking we may say that each gene is responsible not for a unit character . . . but for a unit biochemical process . . . . In general, when a gene is responsible for a step in a synthesis it probably acts by catalyzing the synthesis of an enzyme." This theory, like the plasmagene concept, is a center of heated debate at the present time, and the current status of our knowledge does not warrant a definite conclusion as to either. At the conclusion of Catcheside's review of Gene Action and Mutation, for example, an Addendum was appended in proof to note that in two cases of biochemical mutants it had just been reported that the mutant's requirement is not due to a lack of the specific enzyme involved, as was at first supposed, but rather that the enzyme is present, although in some way inhibited.

Other contributions: W. J. C. Lawrence reviews the Genetic Control of Biochemical Synthesis as Exemplified by Plant Genetics—Flower Colours. It is a great pity that in the 10 years of feverish research on the biochemical genetics of Neurospora, yeast, and bacteria, the promising investigations of the flower pigments appear to have been abandoned. Two of the contributions represent a particular tribute to Garrod, who pioneered in the field of "metabolic errors" at the beginning of the present century. These papers were: Garrod's Conception of Inborn Error and its Development (L. S. Penrose); and The Interpretation of Biochemical Detail Revealed by Inborn Errors (C. Rimington). The latter presents a particularly valuable summary of the researches on the biochemical interrelationships of phenylketonuria, albinism, tyrosinuria, and alcaptonuria in man, together with the newer work on cystinuria. J. G. Carr has summarized current knowledge of Chemically Induced Mutations. G. Pontecorvo, reviewing The Biochemical Genetics of Micro-organisms, and Jacques Monod, writing on Adaptation, Mutation, and Segregation in the Formation of Bacterial Enzymes, have further discussed the "one-to-one" gene-enzyme relation. The facts of enzymatic adaptation in *E. coli* which Monod has presented not only show that each such enzyme depends both on an external stimulus and a specific hereditary factor, but also that a "simple relation" (one-to-one?) holds for adaptive enzymes. But evidence by other workers that several genes may cooperate in the control of a single enzyme makes Monod cautious about taking the one-to-one hypothesis too literally. More recent developments make this stand seem a wise one. The point to emphasize, however, is that there do exist many cases, in many species, of apparently very simple relationships between gene and single biochemical effect. Whether this is always due to the presence or absence of a particular enzyme is secondary.

A brief Summary of the symposium, by A. Neuberger, concludes the publication, which lacks an index.

BENTLEY GLASS

GENERAL AND SYSTEMATIC BOTANY

MORPHOLOGY AND TAXONOMY OF FUNGI.

By Ernst Athearn Bessey. The Blakiston Co., Philadelphia and Toronto. $7.00. xiv + 791 pp.; ill. 1950.

The *Morphology and Taxonomy of Fungi* is, as the author states, not a 2nd edition of his *Textbook of Mycology*, but a completely new and far more comprehensive volume. Furthermore, this new book is not to be regarded as an ". . . encyclopedia of fungi, but rather the foundation upon which to lay the various superstructures of the edifice of mycology." That this foundation is well worthy of the science it seeks to serve can be attested with enthusiasm.

Following a brief Preface is an Introduction, in which the general characteristics of the structure, reproduction, and activities of the fungi are elucidated. A brief account of the History of Mycology is followed by a section on the Rules of Nomenclature, especially as applicable to the fungi. The chapter ends with a key to the major groups and a 3-page bibliography of literature cited.

Chapter 2 deals with the Mycetozoa and Related Organisms and is especially noteworthy for the inclusion of the Labyrinthulales, an important and little-known order usually neglected by both botanist and zoologist. Keys to the more important orders, families, and genera, and a list of literature cited close the chapter.

The next 3 chapters deal with the lower, primarily aquatic Phycomycetes. Since the reviewer's own field of research lies within this area, Bessey's treatment of it was of unusual interest. As he says, the group has been the subject of an extraordinary amount of investigation in recent years, and new ideas on its interrelationships, characters of fundamental significance in determining these relationships, classification, etc., have emerged. These many problems have been handled accurately and fairly by Bessey, and the chapters well represent our modern knowledge of the aquatic phycomycetes.

Subsequent chapters deal with the remaining Phycomycetes and terminate in an excellent account of the curious and little-known Eccrinales, another group seemingly shunned by both botanists and zoologists.

Chapter 8, on the Higher Fungi, compares these with the lower fungi and discusses their biological activities

and morphological features. There follow 8 chapters which consider the successive orders of the Ascomycetes (including certain lichens), the Basidiomycetes and the Fungi Imperfecti. Keys to important genera and lists of literature cited are included.

A rather extensive and comprehensive chapter on the phylogeny of the fungi is followed by one entitled Guide to the Literature for the Identification of Fungi. Here are lists of general works on fungi, host indices, special bibliographies, such as the fungi of man and other animals, the literature of particular groups, etc. The volume concludes with an index in which boldface numerals are employed to indicate pages devoted to main discussions of the topic, a useful device for the reader.

The book is good in format, the illustrations uniformly good (a feature not found in the earlier *Textbook*), and the style simple and readily understandable. Bessey's volume is certainly the most critical and comprehensive modern volume on general structural and taxonomic mycology that has yet appeared. It fittingly crowns a lifetime of devotion to the field by an able investigator, beloved teacher, and a scholar in the finest meaning and tradition of the word.

F. K. SPARROW

THE ACTINOMYCETES—*their Nature, Occurrence, Activities, and Importance. Annales Cryptogamici et Phytopathologici*, Vol. 9.

By Selman A. Waksman. Chronica Botanica Co., Waltham, Mass. $5.00. xx + 230 pp.; ill. 1950.

The author's stated objective in writing this book was to summarize our present knowledge of an interesting and increasingly important group of microorganisms, with particular emphasis on work done by himself and his coworkers. The result is an interesting, up-to-date account of the actinomycetes and their biology, assembled in an easily readable form. The book is well-bound and contains a minimum of typographical errors. The reader will wish that the halftone illustrations were of better quality, but perhaps economy was purposely exercised here to keep the book reasonably priced.

Chapter I, dealing with terminology, phylogeny, and taxonomy, contains an extensive section on the identification of actinomycetes. This section might well have been placed in the second chapter, on the identification and description of important types. The author tends to minimize the inadequacy of present methods of classifying species of actinomycetes. His treatment in the chapters on the morphology, variations and mutations, and metabolism are adequate. The chapter on antagonistic properties and the production of antibiotics, containing much information on antibiotics which he and his associates have discovered, tends to overshadow other antagonistic agents equally noteworthy.

The distribution of actinomycetes in nature, their significance in the decomposition of plant and animal residues, and their roles in plant, animal, and human diseases are well described. An appendix includes the composition of 31 media used in the study of actinomycetes. The bibliography is comprehensive and will prove especially useful. The book closes with a general index and an index to organisms discussed or cited in the text.

This book should prove especially useful to advanced students in bacteriology and soil microbiology, and to all those investigators interested in the field of antibiotics.

KENNETH B. RAPER

THE ECOLOGY AND DISTRIBUTION OF HEPATICAE IN CENTRAL AND WESTERN NEW YORK. *The American Midland Naturalist, Vol. 42, No. 3, Pp. 513-712, November, 1949.*

By R. M. Schuster. University of Notre Dame Press, Notre Dame, Ind. $2.50. 20 pp. + 18 plates. 1950.

This study of the Hepaticae consists primarily of a taxonomic treatment, followed by a much shorter portion of ecological observations. The first part of the book presents a detailed list of "136 species and varieties," with critical taxonomic notes on the hepatics from a region where a thorough study has long been needed.

The author has devoted a great amount of time and effort to make his list complete. Thus it is disappointing to find that his taxonomic treatment of such groups as the *Lophozia-Sphenolobus* complex is not carefully done. According to Article 37 of the International Rules of Botanical Nomenclature, a name-bringing synonym must be cited for a new combination to validate its publication; yet the author has failed to do so in the cases of *Anastrophyllum hellerianus* (Nees) Schuster on p. 63 [575] and *A. minutus* (Crantz) Schuster on p. 64 [576]. Curiously enough, *Cephaloziella byssacea* (Roth.) Warnst. var. *scabra* (Howe) Schuster on p. 36 [548] is validly published, since the synonym is cited. The bryologist will also find that two new subgenera, Euanastrophyllum (p. 65 [577]), and Buchiella (p. 82 [594]) have been proposed without a Latin diagnosis, as expressly required in Article 38 of the International Rules of Botanical Nomenclature. Hence, these two new subgenera are invalid as published. Moreover, an emended subgenus, Euscapania, is proposed on p. 83 [595] without stating the reasons for the change, as Recommendation 32 of the Rules requires.

The keys appear to be clearly and carefully prepared. Moreover, the 18 plates are exceptionally well drawn and as accurate as they are artistically executed.

The second portion (pp. 122–163) includes the ecological and phytogeographical observations. The au-

thor reviews the ecological factors in detail, differentiating two principal hepatic floristic regions. He makes frequent reference to Merriam's "Life Zone" concept; but his observations on habitat factors are largely subjective. Although Schuster treats in detail of hepatic societies associated with forest types of the region, the relative importance of the species composing each community is not always brought out clearly. Quantitative data, and especially diagrammatic maps of these societies, would have added much to their ecological characterization. Moreover, one suspects that some hepatic communities might be difficult in practice to separate sharply from those involving mosses, especially among those which are corticolous.

Typographical errors are altogether too common, as, for example, in the frequent misspelling of Chamaedaphne. On p. 148 [660], one is intrigued to find *Carya cordiformish* (*sic!* hic!), and on p. 152 [664], Primulla.

There are included several paragraphs on "life-zone" affinities and phytogeographical relationships of the liverworts of the region. A glossary, list of references, and an index conclude the book.

W. B. DREW

LES LÉGUMINEUSES DU GABON. *Mémoires de l'Institut d'Études Centrafricaines, No. 1. Brazzaville (A. E. F.).* *By François Pellegrin. Librairie Larose, Paris.* 1200 fr. (paper). 284 pp. + 8 plates. 1948.

The Institute of Central African Studies, established in 1947 in Brazzaville, French Equatorial Africa, for the promotion, coordination, and documentation of research in Central Africa, initiated its program with the publication of a detailed memoir on the Leguminosae found in Gabon. In that part of Africa, this widely distributed and economically important family is represented by 126 genera, with 450 wild and cultivated species. Extensive descriptions, distribution data, and other pertinent comments are given for every species, along with suitable keys for their identification. Several species are described as new, while others are given new names or appear under new combinations of names. Of 3 subfamilies, the Papilionatae are represented by 58 genera, the Caesalpinioideae by 49 genera, and the Mimosoideae by 17 genera. The genus *Macrolobium* is represented by the largest number of species (36), *Millettia* by 25, *Desmodium* by 7, and *Phaseolus* by 4 species, whereas many genera are represented only by one or two species. Included are such well known members as *Phaseolus vulgaris* L. and *Mimosa pudica* L. Valuable features of general interest are the common names and the concise remarks regarding the varied uses of many species. The general reader would have welcomed an introductory chapter, giving such information in greater detail. The monograph is accompanied by an index to common and scientific names. The 8 plates illustrate various parts of representative species. It is hoped that the series will maintain the high standard attained by the first memoir.

THEODOR JUST

WILD FLOWERS AT A GLANCE. *By M. C. Carey; introduction by Henry K. Svenson; drawings by Dorothy Fitchew. Pellegrini & Cudahy, New York.* $2.75. xii + 275 pp.; ill. 1950.

For those amateur or professional botanists interested in the common field and wayside plants of Great Britain and the United States and Canada, this pocket volume will doubtless prove of considerable usefulness. Since colonial days a surprisingly large number of plant introductions into North America, chiefly from Great Britain, have been made inadvertently through the medium of impure agricultural seed shipments, earth ballast in ships, and in various other ways. By similar means, but apparently on a much smaller scale, some of our native plants have become anglicized.

Many of these introduced plants have persisted in the agricultural areas of this country, chiefly in New England and in eastern Canada, where they have all the appearances of being native. Such plants have always been difficult to identify by the use of local manuals. The chief value of this book is that it permits the student to recognize these flowers easily and accurately.

For the assistance of the beginner, the 264 plants described are illustrated in full color and grouped according to flower color. This often makes strange bedfellows phylogenetically, but is doubtless a useful asset for quick reference. In addition to Latin and common names and a short description of flowers, leaves, and stem, the habitat, time of flowering, and indigenous and introduced distributions are noted. Some British plants, such as anemone and hepatica, which have not become established in this country, but which have closely related representatives in our flora, are also described. The Latin names of our native species are helpfully noted in such cases. Each description is also accompanied by the English translation of the botanical name.

SCOTT S. PAULEY

UNCOMMON WILD FLOWERS. *A Pelican Book. By John Hutchinson. Penguin Books, Harmondsworth, Middlesex; Allen Lane, Baltimore.* 2s. 6d.; 65 cents (paper). 254 pp. + 32 plates; text ill. 1950.

This third volume of popular books on the wild flowers of the British Isles, by John Hutchinson, noted English botanist, follows the pattern set in *Common Wild*

Flowers and *More Common Wild Flowers*. The numbering of the flowers, in fact, is continuous with that of the two previous volumes. As the name indicates, this book deals with the "less common" species and some which are quite rare. A key to the genera is supplied and each species is adequately described and figured. The illustrations include 203 black and white drawings by the author, many of which were made from living plants, and a series of photographs of flowers in their native habitats.

ALBERT F. HILL

PLANT MORPHOLOGY

ANATOMY OF THE DICOTYLEDONS. *Leaves, Stem, and Wood in Relation to Taxonomy, with Notes on Economic Uses. Two volumes.*

By C. R. Metcalfe and L. Chalf, with the assistance of M. M. Chatteway, C. L. Hare, R. F. Richardson, and E. M. Slatter. Oxford, at the Clarendon Press (Oxford University Press, New York and London). $25.00. Vol. I: lxiv + 724 pp. + 3 plates; text ill. Vol. II: Pp. 725–1500 + 1 plate; text ill. 1950.

This extensive compilation of data regarding the structure of the vegetative organs of the dicotyledons is essentially a revision and modernization of Solereder's classical *Systematische Anatomie der Dicotyledonen*, which was translated by L. A. Boodle and F. E. Fritsch and published in English by the Oxford University Press in 1908.

The present volumes differ from the preceding ones in a number of significant respects. Although the bulk of the anatomical data, some 1325 pages, is arranged by families in the general sequence proposed by Bentham and Hooker in their *Genera Plantarum*, many new families are recognized and included, making a total of 263. The topical arrangement of data within the families is much improved, and a better balance has been attained in descriptions of the leaf and stem. Solereder's work was based largely upon the study of herbarium specimens and was deficient in information regarding the structure of older stems. During the last 40 years, investigations at Harvard, Yale, Oxford, and many other institutions have provided a broad basis of information regarding the secondary xylem of most dicotyledonous families. The significance of these accumulated data is thoroughly discussed in the introduction to the first volume, and pertinent data with new illustrations are included in the detailed descriptions of the various dicotyledonous families. Unfortunately, relatively little is known at present regarding the comparative structure of roots, of phloem, and of the tissues in the bark of older stems, leaving a void to be filled in the future.

The new volumes by Metcalfe and Chalk provide an extremely useful modern reference work in plant anatomy. An extensive bibliography of literature published since 1908 is included, referring the reader to Boodle's and Fritsch's translation of Solereder's work for a summation of literature published prior to 1909.

I. W. BAILEY

ECONOMIC BOTANY

GARDENS AND GARDENING 1950. *The Studio Gardening Annual.*

Edited by F. A. Mercer and Roy Hay. Studio Publications (Crowell), London and New York. $4.00. 172 pp.; ill. 1950.

The first issue of this English gardening annual to appear since 1940 will bring the reader up to date on the best of the ornamental plants which have been tested during the last decade or more, as well as the old favorites which have not yet yielded their place to newer varieties. In the many chapters, covering broad topics of horticultural interest, there is a noticeable attempt to speak to the informal gardener who does his own handiwork rather than to the owners of formal estates. Austerity has come into the English gardens, but to judge from the many superb photographs it has not taken away any of their loveliness. Although written for the English gardener, his American counterpart can find much in this volume to hold his interest.

C. P. SWANSON

THE WEEKEND GARDENER.

By Dorothy H. Jenkins. Rinehart & Co., New York and Toronto. $2.75. x + 280 pp. 1950.

In these days, when time is a priceless commodity, *The Weekend Gardener* is an acceptable addition to the library of the would-be gardener with little time for reading or day-dreaming. It is written in an easy, familiar style with a sense for the humorous and a kindly touch of sympathy for the struggling gardener, beset with many duties, yet consumed with desire for a garden of his own planting. The book gives the essentials which every dirt gardener should know, as well as many items of information gleaned from experience and not found in the usual garden books.

The chapter on soils and fertilizers is excellent and concise, as is also the chapter on lawns and their care. In the chapter on bulbs there is a table of blooming times, heights at maturity, and correct depths for planting. Those who have tried them will be in accord with such items as her recommendations of the new varieties of summer hyacinth and winter aconite. The hyacinth gives fragrant borders of varied bloom when most spring flowers are gone, and the bright yellow aconite pushes up through the snow in February. Her comments on the lily family are obviously those of an experienced person and well worth heeding. The book

includes a valuable chapter on dependable perennials which are so listed as to give a succession of bloom from April through December. In the chapter on roses the weekend gardener is advised to plant floribundas, shrub roses, and hybrid perpetuals instead of the more delicate hybrid teas, which require considerable care. The hedge roses, the shrub rose, *Rosa hugonis* or Hanson's Yellow, and the Scotch Rose (*R. spinosissima*) are recommended. The reader is reminded that the term "hybrid perpetual is somewhat misleading, since most of these bloom only occasionally during the hot, dry months." Among the most easily grown are Blaze, New Dawn, Dream Girl, Dr. J. H. Nicolas, Mercedes Gallart, and Aloha. Spray treatment for various diseases and pests is discussed.

The essentials for the vegetable garden are given in concise tabular form in some 13 brief pages. There are chapters on small fruits, fruit trees, shrubs, evergreens, vines, insects and diseases, as well as pointers on management. While the author never fails to point to the labor involved in all garden chores, her enthusiasm for gardening is contagious.

EMILY E. TRUEBLOOD

THE COMPLETE GARDEN HANDBOOK.

By Maron J. Simon, Dickson W. Pierce, Beatrice P. Hendrix, and John Elliott. Botanical Consultant: G. L. Wittrock. D. Van Nostrand Co., New York. $5.00. xii + 451 pp. + 32 plates; text ill. 1950.

Every gardener enjoys a good book dealing with his subject. In addition to providing him with the necessary prerequisites for becoming a full-fledged member of the Order of the Green Thumb, a good book bolsters his ego by informing him that certain plants are difficult to culture although the same species under his guidance may grow luxuriantly, it brings him solace and commiseration for his failures, and it provides him with new opportunities to test his skill. This book does all of these things. It is quite complete in its coverage of iter[illegible] in which the home gardener is interested, even the art of flower arrangement, and it is [illegible]ltifully supplied with illustrations, colored as well as black and white. In making recommendations, use is made of frost date maps and a variety of tables to provide the gardener with much condensed and rather precise information. On the whole, it is an up-to-date and useful book, better than most general gardening guides, but it cannot, of course, replace the annual nursery and seed catalogs. No book can do that.

C. P. SWANSON

HOW TO GROW FLOWERS, VEGETABLES AND FRUIT TREES IN YOUR GARDEN. *Grosset's Library of Practical Handbooks.*

By Bruce B. Miner. Grosset & Dunlap, New York. $1.00. x + 92 pp.; ill. 1950.

A good deal of information has been condensed to make this guide for the home gardener. The common problems encountered in planning various types of gardens and orchards are briefly discussed, along with the proper selection and care of plants. Where possible, as with spray schedules and plant descriptions, convenient tables have been prepared for the reader. The author has judiciously avoided a discussion of varieties to be grown, since the volume is intended as a general guide for a beginner who has been bitten by the gardening bug. For particular topics of interest, the reader will not be satisfied with the brief descriptions and bits of advice offered, but the book provides the first steps in the direction of good gardening.

C. P. SWANSON

RHODODENDRONS.

By F. Kingdon-Ward. Pellegrini and Cudahy, New York (printed in Great Britain). $2.50. 128 pp.; 5 plates. 1950.

The genus *Rhododendron*, which also includes the azaleas, consists of over 900 species, and probably more remain to be discovered, since many regions of mountainous Asia have not been adequately explored botanically. Taxonomically it is an extraordinarily diverse genus, a fact which only serves to emphasize its horticultural possibilities, for few genera can surpass the rhododendrons in beauty and luxuriance of flower and leaf display. Ease of interspecific hybridization has also led to the development of many hybrids which have found ready acceptance in the landscape trade. The author, in discussing the horticultural use of so many forms, makes a plea for a wider use of true species in the gardens of England, for he considers the species much superior in general to the hybrids which have gained such popularity. The azaleas are an exception, however. Undoubtedly many in this country feel that the hybrids in both the rhododendron and azalea groups represent distinct improvements over native American species, but the author's experience both as a collector and an exhibitor are not to be disregarded. The reader will gain much from this book regarding recommended species, for the author speaks from first-hand knowledge. The kinds of rhododendrons, their place in the garden, and their care are discussed in an adequate and delightful manner, particularly in relation to conditions in the British Isles.

C. P. SWANSON

THE ESTABLISHMENT OF VEGETATION ON INDUSTRIAL WASTE LAND. *Commonwealth Agri. Bur.—Joint Pub. No. 14.*

By R. O. Whyte and J. W. B. Sisam. Commonwealth Bureau of Pastures and Field Crops, Aberystwyth, Wales, and Commonwealth Forestry Bureau, Oxford, England. 10s. xiv + 78 pp. + 34 pl. 1949.

The reclamation of lands devastated by mining operations poses a difficult problem because of the unproductiveness of the exposed soils. Its solution is becoming more necessary, however, both from a landscape as well as an economic point of view. The authors have surveyed the problem from a world standpoint, and have presented methods of reclamation which should assist conservation departments in quickening their task and in insuring their success. There remains no doubt that reclamation is a step drastically needed in many industrial communities.

TIMBERLAND TIMES.

By Eugene Davenport. University of Illinois Press, Urbana. $3.00. 274 pp. 1950.

By writing this book, the late Dean Davenport of the University of Illinois College of Agriculture has done much to preserve for future generations the details of life in the hardwood forest regions of pre-Civil War days. If you want to know how a shaving horse was used, the role of the all-important axe, the price of a day's labor, the fun of a bussing bee, or the distinctions made by the pioneers among the merchant peddlers that visited them, the answers are here. They come as honest retrospections of a man who loved the land. He tells of maple sugar as a cash crop—an almost unique source of wildcat money with which to purchase the few items the pioneers could not make themselves, or do without. Modern readers may be surprised at the complexities in felling a tree, then an everyday task which was thought out even to the detail of when the small boy should hold the excited canine to prevent his being caught by the toppling trunk. The book is a most enjoyable presentation of a time that must interest every American.

LORUS J. & MARGERY J. MILNE

THE MANAGEMENT OF FARM WOODLANDS. *Second Edition. American Forestry Series.*

By Cedric H. Guise. McGraw-Hill Book Co., New York. $4.00. xii + 356 pp.; ill. 1950.

This book is designed primarily to meet the requirements of college students not taking a professional forestry course but who, nevertheless, desire a knowledge of farm forestry. Forest land owners who are interested in mastering the fundamental practices and principles involved in the proper management of their properties will also find it an excellent reference.

The 2nd edition of this book (first published in 1940) follows closely the 1st edition in text and arrangement. The first part is given over to the place of the forests and farm woodlands in the national economy, the structure and physiology of forest trees, and the ecology of forests. Forest mensuration, silviculture, and management are then covered in considerable detail, and followed by chapters on wood utilization and marketing.

In the 10 years that have elapsed, a number of important developments have occurred in the techniques of forestry and, of course, the author has incorporated the recent developments in the new edition. Illustrations using costs and value have also been brought up to date. The new subject of power saws and machine planting is as adequately covered as could be expected in a brief general textbook. Perhaps it should be pointed out that the photograph of a tree planter (p. 223) does not open a furrow as shown on the following page. This is a fundamental difference between machines and may, when the results of comparative survival tests become available, be a most important difference where there is a heavy competing herbaceous cover or scanty rainfall.

The author also has brought out clearly the growing importance of pentachlorophenol as a wood preservative. However, while he has incorporated improved methods of timber estimating, he has neglected to mention the new science of photogrametry; nor has he included among his selected references the excellent book on this subject by Spurr. If this omission is based on the fact that it is not applicable to the 10 to 20 acre farm woodland, then many other discussions which are included are just as irrelevant.

The reviewer considers both this and the 1st edition excellent books for those who desire to find a working knowledge of forestry in a single book. It is far more than a discussion of farm forestry, and to that extent the title is unfortunately restrictive. It is also the first general forestry textbook which attempts to include some techniques applicable to a forest where wildlife production is one of the objectives of forest management.

P. A. HERBERT

DECAY OF TIMBER AND ITS PREVENTION. *(Reprinted by Permission of the Controller of His Britannic Majesty's Stationery Office, British Crown Copyright.)*

By K. St. G. Cartwright and W. P. K. Findlay. Chemical Publishing Co., Brooklyn. $7.50. vi + 294 pp. + 49 pl.; text ill. 1950.

This up-to-date and comprehensive English summary of the problems associated with the deterioration of harvested forest products fulfils a long-standing requirement of foresters and timber users. The subject has previously been treated briefly in various textbooks of forest pathology, but that it is worthy of separate

and more detailed consideration is attested by the wealth of information assembled by the authors of this book.

The introductory chapters are concerned with the causes of wood deterioration, the techniques used in the study of decayed wood, and the physiology of wood-destroying fungi. The principal decays of standing trees, felled timber, and timbers in buildings and various other structures are then discussed in considerable detail. The decay resistance of various composite wood products and the natural durability of timber are described. The final chapters are concerned with methods of wood preservation by the use of chemicals, and the staining of timber by fungi and its prevention.

The book is abundantly illustrated, but the method of reproduction for the photographs has apparently been responsible for loss of considerable detail through lack of contrast. This situation, although regrettable, does not seriously detract from the effectiveness of the well-organized and interestingly presented subject matter.

SCOTT S. PAULEY

ATLAS DES PARASITES DES CULTURES. *III. Maladies Parasitaires, Maladies Non Parasitaires.*

By Raymond Poutiers; preface by R. Jeannel; illustrations by Bernard Couturier. Éditions N. Boubée et Cie., Paris. 450 fr. (paper). 176 pp. + 12 plates; text ill. 1949.

This is one of the semipopular works of which many have been published in Europe but which are singularly lacking in this country. A brief introduction distinguishes the chief groups of fungi. The main portion of the text describes the more important plant diseases occurring upon cultivated plants in France, arranged under the five fungus groups, Archimycetes, Phycomycetes, Ascomycetes, Basidiomycetes, and Imperfect Fungi; those caused by Bacteria and Viruses and by parasitic Phanerogams; and the chief groups of non-parasitic diseases: accidental wounds, injuries due to meteoric conditions, burning by spraying, and poisoning by industrial gases, and faults of nutrition. The chemical control of weeds is briefly discussed. Each disease or group of similar diseases is followed by brief directions for control. The illustrations are mostly good, and the tail-pieces are amusing.

A number of errors mar the work but probably will not reduce its value as a handbook for recognizing and learning the methods of control of the commoner plant diseases of France. From the standpoint of mycology the following may be noted: in the key to the chief groups of fungi (p. 10) there is omitted "C. Eubasidiomycètes"; *Fusarium dianthi* Prill. et Del. is considered (p. 35) to be the conidial stage of *Neocosmospora* sp.; the names *Sphaerella* and *Mycosphaerella* are used indiscriminately (pp. 38, 39); *Sclerotinia* and *Stromatinia*, are used but no regard is given to *Monilinia* or *Botryotinia*, which perhaps deserve to be considered if the old genus *Sclerotinia* is divided at all (pp. 45, 46). In *Tilletia* and *Ustilago* (pp. 50–54) the promycelium is said to be transversely septate into as many cells as the sporidia produced, in spite of the fact that in the former it may remain now septate, and in the latter there are often several sporidia near each cross wall. The description of the fructification of Eubasidiomycetes (p. 65) would apply to the Agaricaceae but not to most of the species included in these paragraphs (*Corticium, Stereum, Polyporus, Trametes, Merulius*). A few typographical errors are noticeable, p. 62, *clavariciforme*; p. 68, spores *40* in number on each basidium; p. 76, *apicola* instead of *apiicola*.

ERNST A. BESSEY

PRINCIPLES OF PLANT INFECTION. *A Text-Book of General Plant Pathology for Biologists, Agriculturists, Foresters and Plant Breeders.*

By Ernst Gäumann. Authorized English Edition by William B. Brierley. Hafner Publishing Co., New York. $8.00. xvi + 543 pp.; ill. 1950.

A translation of the outstanding work *Pflanzliche Infektionslehre*, reviewed in September, 1948 (*Q. R. B.*, 23: 246). In spite of the translator's quotation of the comparison of a translation to a mistress,—"belle, ne peut être fidèle; fidèle, elle ne peut être belle,"—this is both a faithful and an elegant translation.

BENTLEY GLASS

PLANT VIRUSES AND VIRUS DISEASES. *Third, entirely revised edition. New Series of Plant Science Books (edited by Franz Verdoorn), Vol. 23.*

By F. C. Bawden. Chronica Botanica Company, Waltham, Massachusetts. $6.00. xvi + 335 pp.; ill. 1950.

This book represents a thorough revision of the previous edition (*Q.R.B.* 19: 241. 1944). Most of the text has been rewritten and contains much new material, including additional illustrations. The 1st edition, published in 1939, was the first textbook to really deal extensively with the plant viruses themselves. It was written a few years after the epoch-making work of Vinson had indicated the protein nature of tobacco mosaic virus, Stanley had been able to isolate this protein in large amounts in paracrystalline form, and Bawden and Pirie had demonstrated that viruses of this type are ribose nucleoproteins. This first and the two subsequent editions have summarized more thoroughly than any other books our knowledge about the physical and chemical nature of plant viruses.

The present edition goes well beyond the first two, in that new viruses are described, and the expansion of

knowledge over the whole field has been for the most part summarized remarkably well. Not only have the physical and chemical properties of the viruses themselves been covered, but there are excellent chapters on symptomatology, methods of transmission, vectors, mutation, serology, assay methods, taxonomy, control, etc. Most of the text attests the author's decided mastery of the subject matter. Bawden's style is clearcut, readable, and well balanced scientifically. His presentation is objective and unusually free from bias.

Two chapters are somewhat weak compared to the very high quality of the rest. The chapter on host-plant physiology lacks the balanced criticism of other chapters. Reports of different investigators on the metabolism of virus-infected tissues are compared without considering differences in environmental and physiologic conditions that vitiate the comparisons made. In the final chapter on the origins of viruses, the statements concerning the properties of mitochondria in relation to viruses fall far short of the actual information in this field. The facts that the mitochondrial elements of plant cells (which includes the plastids) contain ribose nucleoprotein, and have been shown to be reproducing entities, have not been mentioned. The index lists just two references to mitochrondria, and only one of these has any primary relation to the virus problem. In view of the demonstrated hereditary, enzymic, and pathogenic (in mutant states) capacities of these sub-cellular elements, it will be interesting to note the consideration that may be given them by virologists in the future.

On the whole, Bawden's book is a contribution of major importance not only to virology but to biology in general. This new textbook should be available to all serious workers in virology and plant pathology.

M. W. Woods

Tomato Diseases. *An Illustrated Guide to Their Recognition and Control.*

By Robert McKay; photographs by G. H. McLean. At the Sign of the Three Candles, Dublin. 21s. vi + 107 pp. + 42 pl. 1949.

This book was written primarily to assist Irish growers, seedsmen, and instructors in horticulture to identify and control the different maladies of tomatoes. The book is similar to bulletins published in this country by experiment stations, but is more comprehensive in all respects. The various chapters deal with fungus diseases, bacterial diseases, virus diseases, non-parasitic diseases, miscellaneous troubles, damage due to animals, eel worms, and general observations. The descriptions are good, and almost all of the plates are very good. The more important references are given following the discussion of each disease. There is an author index and a general index. Since so many of the tomato diseases are worldwide in distribution, this book should be of value wherever tomatoes are grown.

Ralph W. Lewis

The A.B.C. of Garden Pests and Diseases. *The A.B.C. Gardening Series.*

By W. E. Shewell-Cooper. English Universities Press, London. 5/- net. 234 pp.; ill. 1950.

This handbook or manual of insect pests and plant diseases, prepared especially for use in the British Isles, is written in a very brief and popular form. The insect pests and plant diseases are described very briefly, and recommendations are given for their prevention and control. Emphasis is placed on protective measures. The chemicals which are recommended for spraying, dusting, or seed and soil treatment are mainly the older ones which have been in general use. Very little consideration is paid to those newer fungicides and insecticides which at the present time are being found very useful in many areas.

C. W. Edgerton

Plant Disease Handbook.

By Cynthia Westcott. D. Van Nostrand Co., New York, Toronto, and London. $7.50. xii + 746 pp.; ill. 1950.

In its first chapter this "reference book for professional and amateur gardeners and those who advise them" deals, in a general and very brief way, with plant diseases and controls. Chapters 2 and 3 discuss garden chemicals and the classification of plant pathogens. Chapter 4, occupying 349 pages, is an alphabetical listing of the different types of diseases from anthracnose to wilts. Under each disease type there is a general description followed by sections headed by the genus names of the various pathogens. The classification of the genus is given and a brief paragraph describes the genus and its pathology. The name of each particular pathogen is then listed, followed by the name of the disease, a description of the disease, and control measures. In many places through this chapter the unimportant diseases are listed with only a few words of description or none at all, while the important ones may extend over a page or two. Chapter 5, of 264 pages, is a check list of host plants and their diseases. This is followed by a list of Agricultural Experiment Stations in the United States, a glossary, a selected bibliography, and an index. There is little doubt that this book will be a great service to those gardeners who have had some training in botany and plant pathology, but who do not have ready access to much literature on this subject. Because the book is so well organized and convenient, it may well find extensive

use among those who advise gardeners, especially among those who are new in such an activity.

RALPH W. LEWIS

GENERAL AND SYSTEMATIC ZOOLOGY

THE ANTS OF NORTH AMERICA. *Bull. Mus. comp. Zool. Harvard Coll., Vol. 104.*

By William Steel Creighton. The Museum of Comparative Zoology, Harvard College, Cambridge, Mass. $10.00 (paper). 585 pp.; 57 plates. 1950.

Welcome indeed is this impressive and masterly volume by Professor Creighton of the College of the City of New York. Here there is at last available, and for the first time since Carlo Emery's classic but now outdated (1893–95) *Beiträge*, an authoritative, comprehensive digest, evaluation, and revision of the taxonomy of the entire ant fauna of North America north of Mexico. As nigh hopeless confusion and variant standards characterize much of the past myrmecological work and literature devoted to North American ants, it is not surprising that Creighton labored more than twelve years in bringing this monograph to completion. Assuredly it is difficult, and perhaps impossible, for any but those who have spent maddening hours endeavoring to place reliable identifications upon some of our ants to realize Creighton's high achievement, and the magnitude of the indebtedness to him owed by entomologists and other biologists.

Following a brief but thought-provoking discussion of the problems of ant taxonomy and nomenclature, and an interesting appraisal of the history of ant taxonomy in North America, there are characterizations of the family, subfamilies, and genera of the Formicidae, along with fine keys (based on the worker caste) to all recognized members of each of these categories, as well as to species and subspecies. The plates illustrate, where known, the queen, male, worker, and wing of the sexual phase, of a representative species of 57 of the 64 genera treated. Each species and subspecies is separately listed, its principal synonymy and taxonomic bibliography given, the type locality and location of types are stated, the range is given, and often also a brief account of pertinent biological and other information is added.

Especially noteworthy is Creighton's abandonment of all taxonomic categories below the subspecific level. This is a welcome innovation indeed, for the tetra-, penta-, and even hexa-nomials of the past have only compounded confusion and created, to use Creighton's words, "an altogether horrendous maze of nomenclature." Whether or not a varietal name was to be elevated to subspecific or specific rank, or to be dropped from valid usage, or the names of species or subspecies were to undergo change, was generally decided on the basis of geographic range and the maintenance or failure of structural identity over that range. For example, where two or more forms occupy common ranges and yet preserve their structural identities without noticeable intergradation, they are accorded specific rank. Forms are treated as subspecies which occupy more or less individual ranges of their own and maintain their structural identity over much of that range, except in contact areas with related forms where intermediate or intergrading types are produced. This procedure resolves most of the former puzzles, and is in the spirit of the so-called "new systematics." But Creighton judiciously avoids the unreasonable extremes of the more enthusiastic "new systematists," and it is a pleasure to read (pp. 15–16) his reaction to a current vogue among some geneticists to give taxonomic names to forms that cannot ordinarily be recognized in field or museum.

A result of Creighton's reevaluation of the described forms is the relegation of nearly 160 names to synonymy. Nevertheless, the total number of ant species recognized is greater than before, since virtually all of the earlier described species retain that rank, and many forms described initially as subspecies attain specific rank under Creighton's criteria. Where, in 1947, some 742 named forms of ant were recognized within our boundaries, Creighton's total rests at only 585.

There is perhaps one item of detail—the index—that may be criticized in this book, for names placed in synonymy are generally not indexed. Thus familiar names commonly used earlier for North American ants like *acervorum*, *scabrinodis*, *sanguinea*, *heeri*, and *mixtus*, to cite only a few, do not occur in the index, and consequently the synonymies under the species lists of *Leptothorax*, *Myrmica*, *Formica*, *Brachymyrmex*, and *Lasius* must be searched to discover just what has happened, and why, to these and many other names of yesteryear. Even currently accepted names are also not always included in the index. While the subspecific forms of *Polygerus rufescens* are all indexed, for example, the name *rufescens* itself is not. But that is a small matter indeed, and we must all be grateful to Creighton for this keen and admirable tool he has placed in our hands. It is his expressed hope that this book will make it possible to do field work on our North American ants with more ease and accuracy than in the past. While this enormous volume will require at least a small rucksack for transport into the field, there is no doubt that it will wholly fulfill its author's modest wish—and very much more—for it opens wide the fascinating field of myrmecology to all who have the time and inclination.

KENNETH W. COOPER

THE TUNICATA, *with an Account of the British Species. By N. J. Berrill. Ray Society, London; sold by*

Bernard Quaritch, London. 27/6. iv + 354 pp.; ill. 1950.

This work, though a volume of very moderate size, must be given extremely high rating among the books thus far published on these animals. The Tunicata, a group of marine invertebrates, though widely distributed, are not very numerous in species and are of little if any economic importance, but they have long been a subject of great scientific interest because of all invertebrates they show the closest relations to the vertebrates, and are regarded as a branch of the Chordata, from which the vertebrates are derived. They have therefore been the subject of much investigation and literature, which however has been scattered in scientific books and journals not to be found except in the largest libraries, and much of it written in foreign languages. N. J. Berrill, who is at present in the highest rank of investigators and authorities on these animals, has brought together in this volume an immense amount of information, much of it not previously available in English works.

His book has, as its title indicates, two principal purposes. Beside the main one of providing a general comprehensive treatise on the tunicates, it gives an admirable account of the British species and a manual for their identification and study. No up-to-date work of that kind has been available, and because of the location of the British Isles, it covers most of the species of western Europe, not only those of northern but many of southern distribution which range northward to the English Channel. It includes also the pelagic tunicates (of which the Salpas and Pyrosomas are the best known forms) which few works include, most of them dealing only with the ascidians or attached forms.

It would be difficult to improve on the way in which the other purpose of the book, to provide a general treatise on the tunicates, has been carried out. Naturally, where there are different opinions and the subject is more or less controversial, the author follows his own views, although usually not without a fair statement of the other side of the question. In general, his views cannot be considered too radical. For beginners in invertebrate zoology the book will probably be too advanced, but for others and for those desiring a convenient and reliable work on the Tunicata for reference purposes it can be unhesitatingly recommended.

WILLARD G. VAN NAME

THE SEA FISHES OF SOUTHERN AFRICA. *Second Impression.*

By J. L. B. Smith, with a message from His Excellency the Governor-General of Moçambique, foreword by B. F. J. Schonland, and illustrations by Margaret M. Smith and other artists. Published for "The Trustees of the Sea Fishes of Southern Africa Book Fund" by Central News Agency, Johannesburg, South Africa. American trade agents: Hafner Publishing Co., New York. $15.00. xviii + 550 pp. + 102 plates; text ill. 1950.

This work is tremendous in scope, admirable in treatment, and magnificent in production. It is essentially an illustrated catalogue of the 1,275 known marine fishes occuring along the coasts of the Union of South Africa and Portuguese East Africa. Each fish is cross-indexed as to principal references and illustration, with diagnostic characters and brief life-history notes. There are distribution charts, an ingenious key based on numbers of spines in the various rays, a bibliography, and two indices. The general sections on fish morphology, biogeography, tides, effects of fishing, and nomenclature are designed to introduce the interested amateur to the complexities of ichthyology—in fact, the entire work is designed to be usable by the ordinary angler, and common names in English, Afrikaans, and native languages are given. This book owes its being to the interest of a wealthy amateur who provided the major part of the money needed for its preparation and thus made it possible for the book to be sold at a price which is sensationally low—a book of this sort, if published by an American printer, would cost the purchaser at least four times as much. The author is known to zoology as the describer of *Latimeria*, and it is fitting that he should have been entrusted with the task of compiling this work. As an ichthyologist who arrived by the amateur route himself, Smith has not forgotten the needs of laymen nor how to enlist their cooperation in securing rare specimens, and he earnestly urges the collector of any rare specimen to "make every effort to get it to a Museum, for it may be new, and may even be named after you." This does not mean, of course, that the book is impaired as a serious contribution to ichthyological literature, for it is a landmark in the study of fishes. Many of the illustrations are original paintings, others are color photographs, and all of them are well done. Probably the colors are not in every case quite right, but no fish pictures satisfy everyone, and to one who has never seen the fishes of South Africa, they are attractive. There seems to be but one flaw in an otherwise excellent volume: the map included is little better than a conventional diagram, and many of the localities mentioned in the text are not indicated on it.

JOEL W. HEDGPETH

RESEARCHES ON THE AMPHIBIA OF OKLAHOMA. *University of Oklahoma Biological Survey.*

By Arthur N. Bragg, A. O. Weese, Harold A. Dundee, Helen Talley Fisher, A. Richards, and Carol Bergthold Clark. University of Oklahoma Press, Norman. $1.00 (paper). 154 pp.; ill. 1950.

This pamphlet consists of ten technical papers on the identification, breeding season, geographic distribution, growth rate, ecology, voice, and ovarian cycle of some amphibians found in Oklahoma. These papers are of the type usually published in biological journals and are not intended to give a comprehensive treatment of the amphibians of this state.

JOHN A. MOORE

A BEAST BOOK FOR THE POCKET. *The Vertebrates of Britain Wild and Domestic, Other than Birds and Fishes. Second Impression.*

By Edmund Sandars. Humphrey Milford, Oxford University Press, London. 10s. 6d. 378 pp.; ill. 1943.

The beasts included in this book are the mammals, reptiles, and amphibians of England, Scotland, Ireland, and neighboring islands. Since there are relatively few reptiles and amphibians in the United Kingdom, the preponderance of the material deals with the mammals, both wild and domestic, terrestrial and marine. Thus the varieties of domestic rabbits, horses, cows, sheep, goats, and pigs are described although no attempt is made to list the breeds of dogs and cats. For each species there is a brief description of its habitat (i.e., range), color and markings, characteristics of the dentition, of the limbs, its food, voice, and gait. The geographic races are briefly described. A small map showing the distribution, a colored illustration, and a drawing of the body showing the internal skeleton help to identify the various forms. For each of the three classes there is additional information of a general nature preceding the systematic portion. The result is a most useful compilation. The author employs a novel short-cut in the use of scientific names: superscripts are used to indicate repetition of a word, thus *Martes*[3] refers to the subspecies *Martes martes martes*. The index is rather unusual—it functions as a glossary and includes terms not in the book but with page references to places where the term might have appeared had it been used. Such tricks as these save space, but perhaps it would have been better to eliminate the section on heredity (especially where man is credited with 64 chromosomes) and to put less emphasis on gait (5 pages, more than allotted to any other topic discussed). A small error occurs with regard to the cat's skeleton, it being stated that no collar bone exists, although the rudimentary structure is actually shown. Elsewhere there are statements that are slightly misleading (e.g., amphibians are said to have skeletons that generally resemble those of the mammals, etc.) but none that would cause any irreparable damage. The *Beast Book* will fit in the pocket and by having it easily available on trips through Great Britain, the various animals seen should be quickly recognized.

HENRI C. SEIBERT

THE LAPWING. *A Field Study Book.*

By E. A. R. Ennion. Methuen & Co., London. 6s. xii + 47 pp.; ill. 1949.

Field Study Books is a new series of publications designed to stimulate the reader to active interest in subjects whose natural setting is the open air. The present number is devoted to the lapwing, a rather striking and easily identified member of the English bird fauna. The seasonal activities of this bird are taken up month by month for the entire year. Usually some particular behavior is selected and amplified with discussions of related activities in other bird species. Thus flocking, courtship display, nesting, and other avian duties are expounded in their logical sequence. Information that is not known about the bird's habits is pointed out or at least intimated. Perhaps this feature could have been expanded even more, since many readers will not be aware of the problems that remain to be solved or that many of them could be worked out by some interested amateur. Although brief and written in a very light style for popular consumption, this book fulfills its purpose.

HENRI C. SEIBERT

OWLS.

By Herbert S. Zim; illustrated by James Gordon Irving. William Morrow & Co., New York. $2.00. 62 pp.; ill. 1950.

This book continues the series of books on various kinds of animals by Zim with the same excellence seen in his others. Interesting and careful illustrations accompany a narration that touches on essentially all important aspects of the natural history of owls. These aspects include the kinds of owls, their methods of seeing and hearing, their efficiency as hunters, their migrations, the structure of their feathers, and so on. The book is a fine introduction to owls for any child with an interest in natural history.

J. CUSHING

GRØNLANDS FUGLE. *The Birds of Greenland. Part I.*

By Finn Salomonsen; plates by Gitz-Johansen; preface by Hans Hedtoft. Ejnar Munksgaard, Copenhagen. £9/-.(paper). 158 pp.; ill. 1950.

A fine quarto book on birds, beautifully produced, is always welcome. *The Birds of Greenland* is certainly one of them, belonging in a category which becomes scarcer every day under the present world conditions.

Its publication has been made possible by the support of the Danish Government. Finn Salomonsen possesses all the necessary qualities for writing on the subject. He is a competent ornithologist, and he has personally studied the birds of Greenland on the terrain. His account of each species is all that can be desired, as he takes into account all the data of previous authors and adds much of his own. His nomenclature is modern, and his account of the distribution, movements, and life habits of the various birds is instructive as well as illuminating. The text is published in two languages, the left half of the page devoted to the Danish version, the right one to the English. This gives satisfaction to many readers in Denmark, Iceland, and Greenland, who are particularly interested, and also to international ornithologists, American and European alike, as the great island and its fauna have elements belonging to both hemispheres. It is an admirable combination. Part I, now published, deals with the Loons, the Petrels, the Swans, Geese, and Ducks, and the Cormorant, which together constitute a very important part of the avifauna of Greenland.

The book is lavishly illustrated by Gitz-Johansen, an eminent artist who also has spent a great deal of time in Greenland. There are 17 full-page color plates, extremely well reproduced, as well as numerous black and white figures at the heads of the chapters. Gitz-Johansen has treated its subjects in an modernistic way which is altogether interesting, pleasant, and unusual. It contrasts happily with many often somewhat tiresome, too pretty, and too well finished pictures in the tradition of bird illustrations in favor since the days of Audubon and Gould. A comparable effort has been made in France by another well known artist, Roger Reboussin, in his book *L'Oiseau chez Lui*, (Paris, 1930). I regret to say, however, that I do not find Gitz-Johansen's work always satisfactory as a representation of Greenland birds. He has not yet acquired, I fear, a perfect understanding of the shape, movements, or postures of different species. To the reader who is familiar with them, some of his birds appear decidedly awkward and unreal. But his treatment of colors and backgrounds is a certain sign of his great talent.

J. DELACOUR

THE YELLOW WAGTAIL. *New Naturalist Monograph. By Stuart Smith. Collins, London.* 12s. 6d. xiv + 178 pp. + 12 plates; text ill. 1950.

This, one of the first of the New Naturalist Monographs, sets a high standard for the series. The volume includes a detailed analysis of the behavior of the British Yellow Wagtail (*Motacilla flava flavissima*). It is based on the author's extensive and careful study of this bird, chiefly in northeast Cheshire during the seasons 1939 to 1945, inclusive. Being written with a full appreciation of comparable studies on other birds, it can serve as a general introduction to bird behavior, particularly the phases included in territory establishment, pair formation, nesting, and the rearing of young. An extensive bibliography enhances the value of the book in this respect. A unique feature is the series of Edward Bradbury's remarkable plates in color illustrating threat display, fighting, and nuptial display. Other appropriate illustrations are from photographs by the author.

An error involving a purely incidental statement unfortunately appears on p. 21. The author assumes a significant variation in day length in the tropics and attributes to this non-existent condition the initiation of northward migration of wagtails from their winter homes in West Africa.

Two chapters not dealing with behavior deserve special mention. One of these is an historical account of the names of the species. This includes an etymological analysis of common names as well as a history of the technical names. The other chapter is a descriptive summary of all subspecies of this widespread Old World species. One of these, the Alaskan Yellow Wagtail, is the only wagtail regularly nesting in the New World. The heads of males of all subspecies are illustrated in color in Edward Bradbury's paintings.

There are two appendices, one a lengthy summary of past and present breeding distribution, the other a concise summary of parasites of wagtails. The former is documented by citations but the latter is not.

The book is written with enthusiasm and clarity. It is based on many hours of careful observation, critically evaluated in terms of the observations and interpretations of others. The publishers are to be congratulated upon the attractive and readable format.

GORDON ALEXANDER

ENTOMOLOGY FOR INTRODUCTORY COURSES. *Second Edition.*

By Robert Matheson. Comstock Publishing Co., Ithaca. $6.00. xvi + 629 pp.; ill. 1951.

In the new edition (see *Q.R.B.*, 20: 91. 1945), new material has been added, the illustrations have been revised and increased in number, many of the keys have been revised and illustrated, and page references to the text have been included. The fundamental character of the book is unaltered.

ECONOMIC ZOOLOGY

THE WAY TO GAME ABUNDANCE. *An Explanation of Game Cycles.*

By Wallace Byron Grange. Charles Scribner's Sons, New York. $6.00. xviii + 365 pp.; ill. 1949.

This book is intended for the general reader who is interested in learning the basic techniques of game management and acquiring the general biological information underlying the development of these techniques. Of the 4 sections, the first is concerned with the biological principles behind game management; the second discusses plant and animal successions; the third, population cycles; and the fourth, the technology of game management

The book is harder to read and longer than might be expected of a popular treatment, but there is no doubt that it should serve to make a novice well aware of the complexities involved in game management and the ingenuity and biological training needed for their solution. Outstanding in this connection is the emphasis upon the concept that the populations of game animals are dependent upon specific plant habitats and fluctuate with the successive rise and decline of these. This point is made abundantly clear, as are many specific technical operations aimed at maintaining particular plant habitats at optimum productive capacity.

To be criticized is the over-emphasis on population cycles as such and the fact that the author presents for popular consumption views that have not been published elsewhere and hence have not been tested by professional criticism. In general, however, the book should serve a useful function in the group for which it is intended. Its efficiency in this respect is increased by the outline form under which the written material is organized.

JOHN CUSHING

PALOMINO *and Other Horses.*

Edited and illustrated by Wesley Dennis. World Publishing Co., Cleveland and New York. $2.50. 249 pp.; ill. 1950.

This is a collection of 14 horse stories brought together and illustrated by the editor. The selection is an excellent one, including the works of such authors as Ernest Thompson Seton, Will James, Mari Sandoz, and Ross Santee. Wesley Dennis has provided a group of fine pencil sketches to accompany the text.

WESTERN STOCK RANCHING.

By Mont H. Saunderson. University of Minnesota Press, Minneapolis; Geoffrey Cumberlege, Oxford University Press, London. $5.00. xiv + 247 pp.; ill. 1950.

For many years following the settlement of the range lands west of the 100th meridian, nearly all the emphasis in livestock ranching was placed upon the animal. In more recent years the limits of the seemingly limitless range lands have become apparent to all, and increasing attention has been given to the problem of land resources. The author has been engaged as a professional range economist for over 25 years and has a wide experience in the country he writes about. He places much emphasis upon the necessity of correlating livestock management, rangeland management, and the use of feed crops in the operation of the individual ranch. The book is written for ranchers, and for agricultural specialists in livestock production, marketing, credit, or range management, as well as those who are engaged in banking or business in the range states. One chapter is devoted to cost standards, cost analysis, and the financial planning of the ranch, and the final chapter describes the Federal public land policy and the problems of Federal public land use.

FREDERICK N. ANDREWS

DOGS OF TODAY. *Third Edition.*

By Harding Cox; photographs by Thomas Fall. Adam & Charles Black, London (U. S. agents: Macmillan Co., New York). 10s. 6d. 137 pp.; ill. 1949.

A well illustrated and readable book for the dog fancier and dog lover, covering 63 breeds of dogs. There is a 1-page popular characterization of each breed written in an interesting and intimate fashion. The introduction covers a general discourse on the origin of the domestic dog, speculative in nature.

THE CARE AND BREEDING OF LABORATORY ANIMALS. *Edited by Edmond J. Farris, and a Staff of 15 Contributors. John Wiley & Sons, New York; Chapman & Hall, London.* $8.00. xvi + 515 pp.; ill. 1950.

This exceptionally valuable book should be in the library of every department engaged in biological investigation. Included in the contents are authoritative discussions on the care and breeding of the monkey (G. Van Wagenen), rat (Edmond J. Farris), mouse (Leonell C. Strong), guinea pig (Heman L. Ibsen), hamster (Samuel M. Poiley), rabbit (Paul B. Sawin), dog (Leon F. Whitney), cat (Alden B. Dawson), ferret (T. Hume Bissonnette), opossum (Edmond. J. Farris), domestic fowl (F. B. Hutt), various reptiles (Clifford H. Pope), amphibians (R. Cranford Hutchinson), fishes (Myron Gordon), and drosophila (Warren P. Spencer). There is also a section by W. E. Dove on the control of laboratory pests and parasites of laboratory animals. This book would undoubtedly be added to the personal library of many more investigators if the price were lower.

DAVID B. TYLER

ANIMAL GROWTH AND DEVELOPMENT

ENTWICKLUNGSGESCHICHTE DES MENSCHEN. *Ein Grundriss.*

By Kurt Goerttler. Springer-Verlag, Berlin, Göttingen, and Heidelberg. DM 21.— (paper); DM 24.— (cloth). xii + 290 pp.; ill. 1950.

Kurt Goerttler, in entitling his book *Entwicklungsgeschichte des Menschen*, has interpreted "Entwicklungsgeschichte" in its broadest sense, and only about a third of the volume deals with mammalian embryology proper. He introduces the subject with a long section (60 pp.) on vertebrate phylogenesis, followed by a slightly less extensive (40 pp.), but fully detailed, exposition of the laws of fertilization and genetics. The remaining two-thirds of the book is devoted to developmental phenomena in the narrower sense: two sections, which concentrate on amphibian and bird development, respectively, limit themselves to a description and interpretation of germ-layer formation and of the development of the circulatory system; the final section discusses the formation of the germ-layers in mammals and man, as well as human implantation and gestation. The book thus is selective rather than comprehensive, and the material chosen for presentation is discussed with great attention to detail.

The factual exposition is lucid, and illustrated by excellent figures. The author is perhaps at his best in the discussion of data in his own special field, namely in the study of morphogenetic movements, though it is unfortunate that in his discussion regarding these movements in the chick he relied on the earlier vital staining work and made no reference to Spratt's results (1946) which necessitate their reinterpretation. The book may seem somewhat philosophical to the taste of the American student, and its outlook is frankly teleological. So far as the organization of his material is concerned, the author has succeeded in the task of presenting his general material as a frame work in which the strictly embryological data are integrated.

JANE OPPENHEIMER

LA CHIMIOTÉRATOGENÈSE. *Réalisation des Monstruosités par des Substances Chimiques chez les Vertébrés. Encyclopédie Scientifique—Bibliothèque de Biologie Générale.*

By A. Ancel. G. Doin & Cie., Paris. 1,600 fr. (paper). 397 pp.; ill. 1950.

Shortly before the outbreak of the second world war P. Ancel, then at the University of Strasbourg, began to report on a long series of experiments concerning the experimental production of malformations in chicken embryos by chemical means. Heretofore his results have been available only in many brief and scattered communications, but the present book gives an integrated summary of Ancel's observations and discusses their significance in relation to the findings of other investigators.

The first section of the book deals with the teratogenic responses to which the various organ primordia are subject. An introductory chapter discusses the bearing of physical agencies, of operative procedures, and of post-operative temperature factors on the origin of abnormalities and their importance as sources of methodical errors. Some chemicals interfere with normal development by causing localized hemorrhages, thereby leading to secondary defects. Such cases are discussed in the second chapter. There follows (Chap. 3) a systematic description of the various malformations which arise in more or less specific response to definite chemical compounds. Chapter 4 contains a brief discussion of nutritional (vitamin) deficiencies as causes of abnormal development, followed (Chap. 5) by a summary of those experiments in which defective progeny was obtained via effects on the maternal organism during pregnancy. Some generalizations drawn from the reviewed evidence complete this section of Ancel's book. In a short second part an attempt has been made to discuss the teratogenic effects from chemical viewpoints. It appears, however, that the author does not feel justified to go beyond an enumeration of those substances which have a more or less specific effect. The final section contains a detailed discussion of the developmental mechanisms which can be elicited by chemical treatment and which are responsible for particular defects.

Ancel's book is an important contribution to a field which, chiefly because of genetic studies, has assumed much new interest in recent years. The author's own experience and emphasis are chiefly those of the experimental morphologist and, as a consequence, his discussions sometimes omit or touch only briefly on those aspects which are of primary interest to the geneticist. To all persons, however, who are interested in vertebrate embryology, whether normal or abnormal, Ancel's book brings a great wealth of new material.

WALTER LANDAUER

RADIOGRAPHIC ATLAS OF SKELETAL DEVELOPMENT OF THE HAND AND WRIST.

By William Walter Greulich and S. Idell Pyle. Stanford University Press, Stanford, Cal. $10.00. xiv + 190 pp.; ill. 1950.

It has long been realized that the conventional correlation tables for age, height, and weight are often very unsatisfactory for determining the developmental status of children. The latter is much more accurately indicated by the degree of skeletal maturation which, in turn, is related in a remarkably high degree to the changes in the reproductive system. Since the skeleton matures normally as a unit, it suffices, as a rule, to examine it only in part. The hand is not only

readily x-rayed, but is particularly suitable as an indicator of bony development, since its skeleton changes continuously with growth. From the skeletal status of the hand the expert is able to predict the age of expected maturity and to determine the progress a child has made toward adulthood, while the rate of skeletal development is found from repeated hand films. Any interruption of growth, due to illness, certain dietary inadequacies, or other causes, is clearly reflected in the formation of the bones. These general conclusions from studies on very extensive observations on normal white children have been systematically and convincingly demonstrated in this scholarly report, which is generously illustrated by adequately reproduced, selected x-ray photographs and instructive diagrams.

It is somewhat puzzling that the title refers to the "hand and wrist," as if the wrist were not a legitimate part of the hand. The fact that the distal epiphyses of the forearm are included can hardly serve to explain this point.

The authors repeatedly give due credit to the late Prof. T. W. Todd, who initiated and planned this important investigation of the Brush Foundation, most ably continued by Greulich over a period of many years. This splendid atlas will be indispensable to pediatricians, anatomists, physical anthropologists, and coroners.

A. H. SCHULTZ

ANIMAL MORPHOLOGY

L'ORGANISATION DES OS.

By P. Lacroix. Éditions Desoer, Liège; Masson & Cie., Paris. 950 fr. (paper). 230 pp.; ill. 1949.

It is stimulating to receive a monograph on a biological specialty from a foreign source. Such publications offer treatments which, in spite of international co-operation among scientists, are bound to differ from similar publications originating in this country. The volume under consideration is particularly welcome since it deals with a topic whose complexity has proved a stumbling block to both elementary and advanced students, to say nothing of those whose duty it is to tell the story of bone to the uninitiated.

The introduction points out the existence of two disciplines devoted to the study of bone organization, one using principally the microscope and the x-ray tube, and the other the techniques of biochemistry. The material presented here is derived from the former discipline, with help from the latter wherever clarifying evidence is available. Several introductory chapters are devoted to normal development and structure at both gross and histological levels. The greater part of the book deals with experimental techniques, with emphasis on tissue relationships as revealed by grafts and explants.

The chapters on normal bone structure and growth are in accord with current conceptions. Many points have been clarified by a description of phenomena largely or completely excluded from routine accounts. Instead of emphasizing the obvious but anatomically meaningless "Maltese cross" of Haversian systems under polarized light, attention is called to the alternating light and dark bands, each corresponding to a lamella. Their cause is explained, as is the way in which their patterns reveal variations in the lamination of the systems. Considerable emphasis is put on the significance of the metaphysis, which demonstrates a reversal of the usual process of external apposition and internal resorption. Here, as the epiphysis recedes, the diameter must be reduced to the lesser dimensions of lower parts of the shaft. This occurs through external resorption and internal (endochondral) apposition, which in some areas takes place without the usual calcified cartilaginous framework. In the normal growing long bone the greater part of the shaft is periosteal, but the metaphyseal surfaces are endochondral. Encircling the cartilage of the epiphyseal plate (cartilage de conjugaison) there is a ringlike structure, the notch of ossification (encoche d'ossification), which has been neglected by most writers. The many allusions to its activities in both normal and experimental material support well the author's contention that it is a critical area of growth in a long bone. The histological picture encountered in long bones from fetal life to old age is excellently described, with proper emphasis on the frequency of individual variations. Drawn primarily from the material of Amprimo and Bairati of Turin, it firmly establishes an idea of the essentially provisional and highly plastic nature of bone at all ages. Whatever may be the extent of variation of bone among individuals, all of the bones of one person have the same histological appearance. This suggests, by the same reasoning which we have used in recognizing bone marrow as an organ, that bone too may be interpreted as an organ. This account of the histogenesis of long bones (Chap. III), is highly commendable, and should come to the attention of all histologists. The growth of bone marrow (largely appositional) and that of periosteum (interstitial) are described and discussed in separate chapters with considerable revealing detail.

The discussions of experimental work are augmented by the author's own experiences in grafting tissues associated with the growth of bone. Grafts placed between capsule and parenchyma in the kidney are more uniformly successful and there is greater subsequent elaboration of tissues than in those transplanted to sites previously used (subcutaneous; in neck or ear). A series of studies too complex to be described in detail here has established the cartilaginous core of the epiphyseal disc as the inductor of skeletal development in long bones; but not to the exclusion of periosteum nor

even marrow, which can, to a lesser degree, form bone and associated tissues under favorable conditions. The induction operates strongly enough to transform into bone a piece of cartilage not originally destined to undergo osteogenesis. Emphasis is placed on an organizing substance (substance organisatrice) located in the cartilage of the epiphyseal plate, and called "ostéogénine." In alcoholic extract this substance produces bone when injected into muscle. It is apparently concentrated in the plate rather than entirely localized there. Similar but quantitatively lesser results can be obtained from periosteum.

One cannot help but be impressed by the broad implications of the vast amount of work summarized in this volume. It is particularly notable that the active factors of osteogenesis are not discretely localized, but are concentrated in key areas. Adjacent or even distant tissues are capable of exerting, mildly, similar effects. That some are non-living is testified by the activity produced by extracts and fixed tissues. This is especially true of bone grafts. Here, a piece of dead tissue somehow contributes to the regenerative potentialities of adjacent living tissue of the same kind, a reaction that brings to mind similar reactions in other tissues capable of regeneration. Interpretations of bone drawn from purely morphological observations need modification in the light of recent experimental work. For example, it has occurred to the reviewer, as doubtless to many others, to describe osteogenesis from the viewpoint of vascular invasion. Most of the visible changes of this complex process can be rationalized by assuming aggression by the vascular system with its accompanying tissues. But much of the virtue of such an approach is dissipated upon recognition of the existence of inductor mechanisms, centered chiefly in the epiphyseal plate. These attract the otherwise passive vascular system to areas where tissues have been previously prepared for ossification. Inductor mechanisms, being invisible, point up the danger of interpreting any continuous process of change on the basis of morphology alone.

The illustrations in the book leave something to be desired. Both inadequate magnification and poor paper impair the clarity of essential points in the microphotographs. The line drawings are satisfactory. The bibliography is good, being especially fine for original 19th century investigations and the more recent European ones. There is also an adequate index. The author's style is somewhat unusual, and sometimes does not read easily. Although the evidence supporting his point of view on controversial questions is usually impressive, some refutations of contradictory evidence are loosely reasoned. The arguments, for example, against Policard's interpretation of the function of the epiphyseal plate (pp. 102–103) are so loose and rambling that sympathy is directed to the opponent However, the occasionally involved and difficult passages are more than balanced by the over-all treatment of major topics, the descriptions of which flow smoothly and create a satisfying picture in the reader's mind. The author's great pedagogical skill is conspicuous here, the main themes of the work being planned, correlated, and interpreted in a praiseworthy manner.

This is not a book to be picked up casually to see what the investigators of bone are doing. Much of its content is involved and requires study. Nor is it a complete coverage of the subject, the question of cytological involvement, among other topics, being almost entirely omitted. While the definitive story of bone thus remains to be told, this monograph is a good account of the phases which it treats, and should be in the library of every serious student of the subject. It should be helpful to all who teach it.

F. N. Low

AN ATLAS OF THE BLOOD AND BONE MARROW.
By R. Philip Custer. W. B. Saunders Co., Philadelphia and London. $15.00. x + 321 pp.; ill. 1949.

This atlas is designed primarily for pathologists, clinical hematologists, and medical technologists, and is devoted principally to a consideration of the normal and pathological physiology of blood formation and destruction. Of especial value is the large number of full size photomicrographs, many in color. It is unfortunate that the author decided not to include a formal bibliography. Nevertheless, this book should prove a useful addition to the personal library of the clinician or general practitioner, as well as the specialist.

DAVID B. TYLER

THE MAMMALIAN ADRENAL GLAND.
By Geoffrey H. Bourne. (Oxford, At the Clarendon Press) Oxford University Press, London and New York. $6.00. viii + 239 pp. + 15 plates; text ill. 1949.

This is a rather cursory compendium of studies on the gross anatomy and zonation of the mammalian adrenal, based in part on the author's own work, particularly on the Australian marsupials. The general style suggests that the author has been cleaning out his files. Some of the material was obtained "without access to laboratory facilities," some from various museums, and "by the greatest stretch of the imagination could not be regarded as satisfactory histological material." Although the author mentions that the histological state of the adrenals varies considerably with age and physiological condition, he catalogues findings in numerous species based on the examination of one to three in-

dividuals, the only physiological conditions mentioned being sex and "maturity." This is accompanied with sketches of sections at very low magnification, which do not inspire confidence in the histological significance of his remarks on zonation in the Metatheria.

The adrenals of the Monotremata appear to lack the Arnold zonation characteristic of the Eutheria. The marsupial most extensively studied was *Trichosurus vulpecula*, the Australian opossum, in which the author has described a spectacular sex dimorphism that in some respects, although not in others, resembles the mouse X-zone sex dimorphism. The treatment of Eutheria is perfunctory. The plates are of very limited value, and by no means present a well balanced illustrative survey of the histology of mammalian adrenals.

EVELYN HOWARD

THE FETAL PIG. *An Introduction to the Anatomy of the Fetal Pig.*

By Grace E. Holstad. Burgess Publishing Co., Minneapolis. $1.50 (paper). 32 pp. 1950.

This is a perfectly straightforward dissecting manual giving instructions for the dissection of the fetal pig. It is thoroughly adequate, and will be useful in courses in elementary biology, comparative anatomy, or embryology which choose to use the fetal pig for dissection. It is to be commended for asking the student to do his own work and to make his own drawings, and it is to the credit of the book that it is largely unillustrated.

JANE OPPENHEIMER

ANIMAL PHYSIOLOGY

SECRETORY MECHANISM OF THE DIGESTIVE GLANDS. *Second Edition.*

By B. P. Babkin. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $20.00. xxiv + 1027 pp.; ill. 1950.

Since the appearance of the first edition in 1944 (*Q. R. B.*, 20: 95), this substantial survey of the problems pertaining to the physiology of the digestive glands has been moderately enlarged. It now includes for the first time sections on "the effect on the secretory activity of the gastric glands of pilocarpine, acetyl choline, and caffeine; on the inhibition of gastric activity by different methods; on pancreozymine; on antagonistic and synergistic activity in the autonomic nervous system; on secretory inhibitory nerves; and on the nervous and hormonal regulation of the pancreatic secretion." Other new findings have been incorporated, and more than 260 new experimental investigations are discussed.

In general, the book tends to emphasize the microscopic anatomy of the digestive glands, and what may be called their gross physiology, but there is as yet little of a microscopic physiology, and correspondingly little if any physicochemical treatment. The literal-minded may find that the title raises expectations which the text does not fulfill. The book is described in the preface as a study "of the mechanisms involved in the regulation of the secretory activity of the principal digestive glands," which is not the same thing as the title implies, which at best reflects a hope of the future rather than a description of the subject matter. The figures of Ludwig and Heidenhain and of Bayliss and Starling stride ubiquitously through the pages, while as yet our generation seems to have contributed much interesting analysis and amplification, but little further resolution. Regarding the fundamental mechanism of glandular activity, the author disarmingly remarks, "One must not forget, however, that as yet only the fringes of the problem have been touched."

EVELYN HOWARD

A SYMPOSIUM ON STEROID HORMONES.

Edited by Edgar S. Gordon; 34 contributors. University of Wisconsin Press, Madison. $6.50. xiv + 396 pp. + 11 plates; text ill. 1950.

This volume signalizes a colloquium on the steroid hormones held in 1949 at Madison, Wisconsin, as part of the 100th Anniversary Celebration of the University of Wisconsin. This included formal presentations, round tables, and open discussions. Inevitably, a good deal of the flavor of a conference is lost in giving, as here, the skeletal portion only, and some of the papers show the lack of the discussions they were intended to provoke. On the whole, familiar ground is covered. Steroids were treated in relation to their biosynthesis; structure and function; metabolism and excretion products; effects on protein anabolism, on blood cells, and on metabolism generally; role in cancer; interrelation with enzyme systems; effects on sex differentiation and behavior; and interrelation with the target organs and the hypophysis. Sex and adrenal steroids receive about equal attention. Marrian has contributed an excellent, though brief, historical introduction. As with much Festschrift material, a good deal of the work reported, if not already published, can confidently be expected to appear elsewhere. Certainly many original experiments and findings are presented here, but the lack of any kind of index will tend to conceal them from all but the most devoted reader of the literature. Those contributions will be found most useful where some sort of positive synthesis of material has been attempted.

H. R. CATCHPOLE

DOCUMENTA OPHTHALMOLOGICA—*Advances in Ophthalmology. Vol. IV.*

Edited by F. P. Fischer, A. J. Schaeffer, and Arnold Sorsby. Dr. E. Junk, The Hague. Dutch Guilders 36.—; $9.60. 362 pp.; ill. 1950.

Unlike Volume III, which consisted of a series of papers oriented around one major aspect of vision, this volume of the *Documenta* contains a collection of heterogeneous material. The reviews are uniformly good, but are so diverse in content that few visual specialists will be interested in all of them.

The first item is a brief obituary of the famous German ophthalmologist, Karl Wessely. Appended is a list of Wessely's publications, which number slightly over 200 and date from 1897 to 1948. The second item is a 90-page article by M. A. Bouman on a Quanta Explanation of Vision. This is a highly theoretical and difficult paper which includes much of the theory that the author has recently published with van der Velden in other places. The third article is a short one by Katharine Tansley on Visual Purple. It summarizes much recent work and attempts to show how satisfactory a general picture of the bleaching and regeneration of visual purple we now have. R. G. Hopkinson next summarizes some Recent Studies of Lighting and Vision, and provides a good bibliography on this topic.

The last five items are essentially concerned with ophthalmological problems. P. J. Waardenburg, writing on Twin Research in Ophthalmology, reviews the evidence for and against hereditary factors in all sorts of normal and abnormal eye traits. His bibliography of roughly 300 items should be extremely valuable to research workers in his field. G. B. Bietti has a paper on Ophthalmic Aspects of Protein Deficiency and Disordered Protein Metabolism, and A. J. Schaeffer writes on Some Aspects of Ocular Pharmacology. Both have extensive bibliographies. The final two contributions are: Protective Glasses for Welding (G. A. W. Rutgers); and Modern Refinements in Tonometry (Jonas S. Friedenwald and Robert Moses).

A. CHAPANIS

ANIMAL NUTRITION

MINERAL NUTRITION OF PLANTS AND ANIMALS. *By Frank A. Gilbert. University of Oklahoma Press, Norman.* $2.75. xii + 131 pp.; ill. 1949.

The accumulation of a vast amount of literature dealing with the mineral nutrition of plants and animals has resulted in a great need for an integrated survey of the more important contributions in this field. It is with this objective in mind that the present book was prepared. The author presents a brief sketch of the early history of plant nutrition, a biological classification of the nutritionally important elements, and finally a discussion of the important agricultural and nutritional aspects of the individual elements, including literature citations. The elements covered are phosphorus, calcium, magnesium, potassium, sulfur, iron, copper, cobalt, manganese, zinc, iodine, boron, molybdenum, aluminum, silicon, sodium, chlorine, fluorine, arsenic, lead, and selenium. On the whole, the author has succeeded in the difficult task of highlighting the subdivisions of the subject sufficiently for the book to serve as a foundation for more intensive research in restricted fields. The treatment given to each of the elements appears to be restricted very definitely along agricultural or medical lines, with a great deal of emphasis on the morphological effects of deficiencies as well as on the structural role of the elements. Unfortunately, there is little or no discussion of the important metabolic functions of minerals in the organism. Some obvious omissions along these lines are the failure to mention (a) the important fact that zinc is a part of carbonic anhydrase, or (b) the importance of phosphate in the energy transfers of the living organism.

The absence of any consideration of the significance of new analytical and purification procedures, so responsible for our recently expanded knowledge of the micronutrient or "trace" elements, is an important omission.

ALVIN NASON

NUTRITIONAL DATA (*Formerly Nutritional Charts*). *Compiled by Harold A. Wooster, Jr. and Fred C. Blanck. H. J. Heinz Co., Pittsburgh.* Gratis (paper). vi + 114 pp. 1949.

The publication, *Nutritional Charts for Medical and Nutritional Specialists*, published and distributed by the H. J. Heinz Company during the past 15 years (*Q. R. B.*, 22: 356, 1947) has now blossomed forth into a modern and more extensive form under a new title. This booklet represents a compilation of the basic principles and facts of nutrition. A tremendous amount of facts and principles, as well as important literature references, has been assembled into a conveniently available and readily digested form. The salient facts about the individual vitamins, amino acids, and mineral elements have been brought up to date and succinctly condensed. The chemical properties and structures, malnutrition symptoms, analytical procedures, availability, distribution, and functions in numan nutrition of the various nutrients are presented. A new section on proteins has also been added. The charts dealing with intermediate metabolism include details of substrates and enzymes involved in the stepwise metabolism of carbohydrates, fats, and nitrogen compounds, and have been recast and modernized. The valuable tables on the Composition and Nutritive Value of Foods have been reassembled and brought up to date. This booklet will serve as a useful reference

manual for those concerned with the theory and practice of nutrition.

ALVIN NASON

EXPERIENCES WITH FOLIC ACID.

By Tom D. Spies. The Year Book Publishers, Chicago. $3.75. 110 pp. + 4 plates + 1 chart; text ill. 1947.

Now of historic interest only, because of the rapid development in the field of folic acid studies, this monograph still warrants notice because it records the discovery of the vitamin; the author's pioneer work in its therapeutic use in nutritional macrocytic anemia, pernicious anemia, and sprue; and its identification as pteroylglutamic acid or closely related substances isolated from yeast or liver, as well as spinach.

GENERAL PHYSIOLOGY

THE PHYSIOLOGY OF WORK AND PLAY. *A Textbook in Muscular Activity.*

By Sarah R. Riedman; illustrated by Ida Scheib. Dryden Press, New York. $4.90. xii + 584 pp.; ill. 1950.

This is a first-rate textbook on the physiology of exercise. It may be argued in some quarters that since the book was designed primarily for undergraduates in the fields of physical education, pre-physical therapy, and recreation, it may be beyond the capacities of the average student in those fields. However, the style is exceptionally clear, and since each chapter takes into account the diversified scientific backgrounds found among physical-education students, this obstacle is overcome.

The book is unique in many respects. In the first place, the author has prepared a text suitable for elementary (and even graduate) students in the physiology of exercise by resorting principally to the original and current literature in the field. There is little, or no, rehashing of the textbooks of others; quite the contrary, the author has made a distinctly original contribution in this piece of work. Secondly, the illustrations are, for the most part, original or carefully selected ones from the original papers referred to in the preparation of each chapter. Finally, each section is concluded with a brief summary and an exceptionally good bibliography.

Of course, one may find some errors of fact and, in a few instances, I would disagree with the interpretation or even, on occasion, the author's ability to evaluate some of the evidence she has selected to support some premise, as, for instance, the effect of "available" glucose on work performance (p. 164); but such criticisms are of a minor nature and certainly in no way detract from the overall excellence of the text.

I believe that the use of a textbook such as this will stimulate a greater number of physical educationists to take advantage of their many opportunities to do investigative work in a field that contains many items of general physiologic interest. It is my opinion that this is one of the best textbooks in the field and that its use will go far to elevate professional standards.

DAVID B. TYLER

MUSCULAR CONTRACTION. *A Topic in Molecular Physiology.*

By W. F. H. M. Mommaerts. Interscience Publishers, New York and London. $4.20. x + 191 pp. + 1 plate; text ill. 1950.

It is gratifying to note that at a time when muscle physiologists and biochemists are primarily concerned with the details of muscular contraction there is at least one who is willing to record the present status of the problem as a whole. Mommaerts' monograph is a fairly complete and balanced presentation of the significant experimental studies and concepts bearing on the mechanism of muscular contraction (exclusive of excitation and relaxation). Although he occasionally argues strongly for certain theories and interpretations in preference to others, the author makes it clear that the present status of the problem does not warrant the construction of such theories.

In the introductory chapter the author presents the rationale behind the current research on muscle proteins by describing a series of experiments in which a muscle is broken down until only the contractile proteins are left. Threads spun from these proteins constitute, in the author's opinion, a partial reconstruction of the physiological machine in so far as their ability to shorten under physiological conditions is concerned. Inasmuch as two-thirds of the book is concerned with the properties of these proteins, it is necessary that the reader accept this rationale if he expects to appreciate the relevance of most of the material presented in the book. The second and third chapters cover the qualitative and quantitative aspects of muscle metabolism. In particular, the development of our current concept of glycolysis is traced, and its connection with mechanical activity and heat production is discussed. The fourth chapter is devoted to a discussion of the sequence of events occurring during mechanical activity and their possible relationships to the metabolic activity. Among the events covered are: pH changes, volume changes, heat production, and transparency changes. The discussion of the "Fenn effect" given here is the usual one arguing for preenergization over postenergization theories. There is no reference to Ramsey's discussion (*Medical Physics*) which pointed

out that the "Fenn effect" is not necessarily incompatible with postenergization mechanisms.

Chapters 5 through 14 contain a detailed presentation of the chemistry and physics of myosin, actin, and actomyosin. These chapters contain numerous quantitative comparisons between studies in vivo and in vitro, of interest to the student as well as the research worker. On the basis of these quantitative comparisons and other pertinent facts, Mommaerts concludes chapter 14 with a working hypothesis which pictures the fundamental event of muscular activity as a topochemical reaction of ATP with actomyosin in which the free-energy effect is not connected with ATPase activity. The final chapter, Problems and Interpretations, begins with an investigation of the extent to which the previously stated working hypothesis agrees with the physiological facts. The chapter concludes with a mention of some pertinent but unexplained experiments and a brief critique of Wohlisch's and Meyer's theories of the origin of muscular tension.

There is little doubt that the author has succeeded in presenting a complete picture of the present status of our knowledge and concepts of muscular contraction. By presenting the rational foundations behind the current research on muscle proteins in the first chapters, the author provides the reader with the sine qua non for accepting the interpretations based on this work. For those who accept this rationale, the book will be a valuable reference; for those who do not, it should act as a strong stimulus to further research.

F. D. CARLSON

PHYSIOLOGY OF MOTION. *Demonstrated by Means of Electrical Stimulation and Clinical Observation and Applied to the Study of Paralysis and Deformities.*

By G. B. Duchenne; translated and edited by Emanuel B. Kaplan. J. B. Lippincott Co. Philadelphia. $18.00. xxiv + 612 pp. + 1 plate; text ill. 1949.

Guillaume Benjamin Amand Duchenne was born in Boulogne, France, in September, 1806. In 1825 he entered the Medical School of Paris, graduating in 1831. Four years later he became interested in the use of the faradic current in the treatment of certain diseases. These studies, begun in Boulogne and continued in Paris, culminated in his classic *Physiologie des Mouvements*, which appeared in 1867. Duchenne was not only a first-rate experimentalist but also an excellent clinical observer. Kaplan credits him with the discovery of locomotor ataxia, progressive muscular paralysis, and glossopharyngeal paralysis, and with the location of the lesion of poliomyelitis in the anterior horn of the spinal cord. He was, to quote his translator, "one of the greatest clinicians of the brilliant period of French neurology."

The enormous amount of material contained in the present volume was secured by Duchenne from various sources. His observations were based above all on clinical experience. But in addition he stimulated, with consummate skill, individual muscles and groups of muscles in the living human and the recently dead, carried out experiments on animals, and made numerous dissections. His material comprised not only normal individuals but also persons exhibiting various pathological conditions. The scope of his work is so vast that any attempt to discuss it would involve many pages. It covers almost the entire system of the striated musculature. Save for certain teleological points of view that largely reflect the time in which it was written, the manner of presentation is essentially modern. Indeed, as an analysis of muscle action, it is far superior to those found in many current textbooks. In the words of the translator, it is "an untapped treasure of important information." It is to be hoped that Kaplan's excellent translation will serve to correct the general neglect of Duchenne's truly monumental work.

As for the translation itself—the first into the English language—it has obviously been done with great care and competence and is deserving of the highest praise. Kaplan has wisely chosen to translate the peculiar French anatomical terminology used by Duchenne into the anglicized form of the BNA. He has also corrected a fairly large number of errors found in the original text, involving anatomical names, cross references, and even anatomical descriptions. The usefulness of this translation cannot be overemphasized. Duchenne's work still is and will continue to be of great importance to a variety of workers—anatomists, physiologists, physiotherapists, orthopedists, neurologists, and clinicians in general. Anyone who uses this book—and it is to be both hoped and expected that many will do so—will certainly feel indebted to Kaplan for his unselfish labors.

W. L. STRAUS, JR.

BIOPHYSICS

POCKET ENCYCLOPEDIA OF ATOMIC ENERGY.

Edited by Frank Gaynor. Philosophical Library, New York. $7.50. 204 pp.; ill. 1950.

The author has collected a quite comprehensive dictionary of terminology used in nuclear science. Since such a compilation is intended for use by non-scientists, it is especially unfortunate that a rather large number of errors is noticeable, upon only casual inspection.

L. J. MULLINS

BIOPHYSICAL RESEARCH METHODS.

Edited by Fred M. Uber. Interscience Publishers, New York. $9.50. ix + 667 pp.; ill. 1950.

This book is another addition to the growing collection of books on instrumental biophysics. It is written by a group of authors, each one an expert in his subject. The topics range from some of the classical physical chemical techniques used in biology, such as osmotic pressure, viscosity, temperature measurements, calorimetry, and electrophoresis, through microscopy (including a nice introduction to phase microscopy), freezing techniques, ultrasonics, bioelectric measurements (using AC and DC amplifiers), absorption and action spectra, and x-rays, to such recent subjects as the electron microscope, nucleonics, and tracer techniques. A certain unity has been achieved by labeling the techniques biophysical, and by having each author cover the same five points in his discussion. The latter has resulted in a tendency to unimaginative writing in some places. No attempt has been made to cover all methods that could be called biophysical, which would be impossible in a volume of this size.

The reader will find the book a good source of concise, qualitative, yet critical accounts of methods with which he is unfamiliar. Here he will find the rudiments of each subject treated in a fashion that is easy to understand, together with an expert's opinion of the possibilities and limitations of the techniques involved. He will then be ready to consult more technical treatises and papers, a task facilitated by the inclusion of an adequate bibliography at the end of each chapter.

At the beginning of the book there is an amusing chapter, complete with cartoons and entitled "Avoid fruitless experiments," in which the editor attempts to reduce the pursuit of science to a formula. The reviewer is glad the editor wrote this chapter, but wishes he had left it out of the book.

PHILIP W. DAVIES

BIOCHEMISTRY

A TEXTBOOK OF BIOCHEMISTRY. *New Second Edition. By Philip H. Mitchell. McGraw-Hill Book Co., New York, Toronto, and London.* $6.00. xviii + 695 pp.; ill. 1950.

This second edition (see *Q. R. B.* 21: 400. 1946) has been thoroughly revised, with particular attention paid to the chapters dealing with the kinetics of enzyme action, intermediary metabolism, carbohydrates, proteins, lipids, and vitamins. In his chapter on Carbohydrate Metabolism, the author has completely overlooked the very important contributions of Drury's group, particularly in respect to the mechanism of insulin action. This, in my opinion, is a serious oversight.

DAVID B. TYLER

CHEMISTRY AND INDUSTRY OF STARCH. *Second Edition, Revised and Enlarged. Edited by Ralph W. Kerr. Academic Press, New York.* $11.50. xii + 719 pp.; ill. 1950.

This book was intended to survey the subject of starch for the carbohydrate chemist as well as the technologist concerned with the production and utilization of starch products. In the preface to the first edition (1944), the editor stated: "The purpose of this text is to review and bring up to date our accumulated knowledge of starch and of the more important products derived therefrom." The second edition has been rewritten to include important advances made in this active field during the interim between the two editions. Ten authors, most of them recognized experts in their particular specialties, have participated in this effort. Many of the chapters have been rewritten and enlarged. There has been a good deal of pruning of older work now obsolete, and new chapters have been introduced dealing with a wider field of interest. The chapter on the structure of starch has been brought up to date and the discussions on the technology of starch, particularly with regard to its manufacture and uses, have been extended. A new chapter has been added on miscellaneous uses of starches that have assumed technological importance in recent years; and still another on the analytical methods employed for the determination of starch and starch products.

The book is up to date, and has the great advantage of having been edited by an author who is thoroughly familiar, at first hand, with the wide field it covers. In general, it may be said that the editor has succeeded in preparing an extremely fine account of the chemical and biological reactions which starches undergo, and of the industrial and other uses to which they are put. Many readers will be grateful for the opportunity to use this volume as a guide to the literature on the subject, to which there are copious references, and for a general survey that brings together an enormous amount of research.

W. Z. HASSID

BIOLOGICAL OXIDATION OF AROMATIC RINGS. *A Symposium Held at London School of Hygiene and Tropical Medicine on 12 November 1949. Biochemical Society Symposia No. 5. Organized and Edited by R. T. Williams. Cambridge University Press, New York and London.* $2.00 (paper). 96 pp.; ill. 1950.

This publication consists of 7 critical discussions by various specialists, given at a symposium at the London School of Hygiene and Tropical Medicine on November 12, 1949. The papers deal with the oxidative and other chemical changes occurring in benzene derivatives or other cyclic compounds in the animal body or in contact with bacterial cells. Those interested in this special field of biochemistry will find it a valuable contribution. Each paper is followed by many refer-

ences. For biologists in general, the symposium can be summarized by saying that the oxidations occurring in vitro differ considerably from those occurring in vivo. Furthermore, the changes brought about by bacteria differ from those taking place in the bodies of animals.

WALTER C. TOBIE

MULTI-ENZYME SYSTEMS. *Four special lectures given to University College, London, in May 1948.* *By Malcolm Dixon. Cambridge University Press, New York and London.* $1.75. 103 pp. 1949.

Cellular biologists concerned with the problems of the functioning of intact cells will find much of interest in these lectures not only for their content, but perhaps even more important, for their intent. This represents a recent and growing trend on the part of biochemists toward the synthesis of the facts derived from biochemical research into schemes relevant to the intact functioning cell.

The first chapter describes the various types of linkage which can exist amongst several enzyme-controlled reactions, and the conditions required for such coupling. Enzyme systems can in principle be linked by having a common reactant. As is well known, in many of the instances which can be identified, the common reactant involved acts either as an energy- or a hydrogen-transfer mechanism. The second chapter details systems linked by virtue of energy-transferring compounds, e.g., the adenosine triphosphate system. The third chapter discusses interactions amongst hydrogen-transferring systems, and employs the rH scale first proposed by Mansfield Clark. The fourth and final chapter develops an analogous method for the treatment of phosphate transfer, using a quantity rP defined as $-\log P$, where P is the molar concentration of inorganic phosphate. From a pedagogic point of view, the last two chapters in particular are excellently conceived and executed.

One of the most fascinating features of this book stems from the methodology it proposes. Many cellular physiologists will undoubtedly experience a feeling of profound awe in the face of the unbounded faith in synthetic ingenuity which characterizes the philosophy underlying this as well as other such attempts. The credo followed in such endeavors, which proceed from some of the isolated components to the complexity of the intact functioning cell, is put simply and well by the author in the opening remarks of his first lecture: "The most effective way of finding out how any complex mechanism works, for example, a stopwatch, is first to take it to pieces and to study the isolated parts separately; after this to see how they fit together, and how they are connected functionally; and finally to reassemble them, building up trains of wheels, etc., until the mechanism is complete."

Few would deny the value which attends the existence of this philosophy as well as its active prosecution. It has in the past yielded information indispensable to an understanding of cell physiology, and it will undoubtedly continue to do so in the future. However, even its most optimistic proponents will likely admit that it takes a genius of high order indeed to deduce principles of cell physiology from the biochemistry of extracted enzymes. Every now and then a man of the requisite mental caliber does come along and extracts from the soups and breis of the homogenating biochemist a general concept that is fundamental to our understanding of the living cell. A mental tour de force of this magnitude was achieved by Fritz Lipmann in his famous 1940 paper (*Advances in Enzymology*, Volume 1), in which he synthesized the facts derived from the study of isolated enzyme systems into a generalized concept of energy generation and utilization.

Such bursts of insight are rare and when they occur, compelling. Their brilliance should not, however, blind us to the obvious. Concepts derived from isolated systems must pass the test of relevance before their general applicability to viable functioning cells can be accepted. It would be a profound misconception of the significance of recent contributions in biochemistry and a disservice to their true value if these advances were not subjected to rigorous test by experiments with intact cells. Yet, if the present trend continues in cellular physiology, this will indeed be the final result.

More and more people trained in the study of cell function are abandoning this field to become "poor men's biochemists." The lacunae thus created will not in all likelihood be adequately filled by biochemists. While the founders of modern enzymological biochemistry were men with broad biological training and profound insight into biological problems, the same cannot, for the most part, be said for the younger practitioners of the science. The modern era of the acetone powder, the dried cell preparation, and the homogenate, with its fleeting contact with living cells, provides the recently trained biochemist with relatively scant experience with the functioning of intact tissues. Thus if the cell physiologist should effectively disappear, there would be few persons specifically trained to competently test or question the relevancy of biochemical facts to cell behavior, or the adequacy of any general concepts which may be derived from them.

It may perhaps be true that cellular physiology has outlived its usefulness. This, however, is a conclusion which should hardly be arrived at by default. Books such as the present implicitly deny the validity of such a conclusion. The cell still remains to be studied. It is the sole criterion of validity and relevance on questions of cell function and mechanism.

S. SPIEGELMAN

METHODS IN FOOD ANALYSIS *Applied to Plant Products.* *By Maynard A. Joslyn. Academic Press, New York.* $8.50. viii + 525 pp.; ill. 1950.

This book is the outgrowth of a series of lecture notes and laboratory directions developed by the author over a series of 20 years or more. Believing that there is need for a textbook in the field of food analysis that would stress principles rather than practices, be critical rather than comprehensive, and include appropriate discussion of recently acquired analytical tools, the author has designed the volume along these lines. Its contents include: 3 chapters devoted to introductory and basic material—sources of information, statistical measures for appraising data, topics dealing with the collection, preparation, and preservation of samples; 3 chapters on procedures employed in determining moisture, ash, and in making extractions and separations; 7 chapters on physical instruments and techniques, including specific gravity, refractometry, polarimetry, colorimetry and spectrophotometry, viscosimetry, and methods dealing with potentiometric measurements and the determination of pH and buffer capacity; and 7 chapters on various plant constituents —acids, alcohols, carbohydrates, nitrogenous compounds, and tannins. Discussion, as stated in the introduction, is limited to chemical and physical procedures applied to fruit and vegetable products; references to microanalytical, bioassay, and bacteriological methods are purposely limited. Quality evaluation and techniques for assuring uniformity and further improvement of product are emphasized rather than the detection of adulteration, addition of possibly toxic agents, or the development of criteria of incipient spoilage.

The author has achieved his aims and produced a volume which should be of definite value to food chemist, student, and technologist alike. Presentation of the underlying principles, and the description of instruments employing them, are both clear and detailed, and hence should be of particular interest to the student. Numerous references appear at the end of each chapter and leave little to be desired as to completeness. The format of the book is pleasing and, except on pp. 39–42, where attempts to quote A. O. A. C. methods fail sadly in fidelity, the text is almost free of errors. This volume is essential in the up-to-date food chemist's library.

WILLIAM F. REINDOLLAR

ANTIBIOTICS.

Edited by George W. Irving and Horace T. Herrick. Chemical Publishing Company, Brooklyn. $6.75. viii + 273 pp.; ill. 1949.

This book is simply a collection of fourteen lectures given in a course entitled "Progress in the Field of Antibiotics," sponsored by the United States Department of Agriculture Graduate School in Washington. In the first lecture, entitled Introduction, the speaker discusses the whole problem of the relationship between a chemotherapeutic agent and an antibiotic, and gives the general prospectus of the book. There follow lectures on: The Story of Penicillin, The Role of Microorganisms in the Production of Antibiotics, Development of High-yielding Strains of Micro-organisms for Production of Antibiotics; The Government Certification Program for Penicillin; The Commercial Production of Penicillin; Production of Streptomycin and Other Antibiotics by Actinomyces; Outline of the Chemistry of Streptomycin; The Clinical Use of Penicillin and Streptomycin; Tyrothricin and Gramicidin; Antibiotics Other Than Penicillin, Streptomycin and Gramicidin; and Basidiomycetes as Possible Sources of Antibiotics. The last two lectures are on Antibiotics From Higher Plants and Antibiotics in Veterinary Medicine.

As would be anticipated, there is considerable overlapping between the material presented in the different lectures, but the editors frankly admit that no particular effort was made to avoid this. The story of the development of penicillin, although by no means detailed, is fairly accurate. This series of lectures did well to bring together the pertinent information concerning antibiotics which was available at the time the lectures were given. On the other hand, the book contains very little that is not well known to students in the field of antibiotic research and it can hardly be recommended as a textbook, reference book, or a laboratory tool. The historian would hardly find it useful, and it contains little that would be of value to the biologist.

W. E. HERRELL

LE PRINCIPE DES ANATOXINES ET SES APPLICATIONS. *Travaux d'Immunologie.*

By Gaston Ramon. Masson & Cie., Paris. 800 fr. 231 pp. 1950.

G. Ramon, the well-known French immunologist, reports in this book on his discovery of anatoxins and on the results obtained from their application in different countries. Anatoxins are prepared from microbial or vegetal toxins by the action of formaldehyde at 40°C. While the toxicity of the toxins is destroyed by this treatment, their antigenic properties are preserved, so that injection of anatoxins leads to the formation of antitoxins in the injected organism. In this manner immunity against diphtheria, tetanus, and other toxemic infections can be achieved.

Ramon's book differs from most scientific monographs in that the author includes many personal remarks. In the Preface he describes why and how he investigated toxins. In the main part of the book he quotes many favorable reports on the use of anatoxins, and criticizes those who did not recognize the im-

portance of his discovery. Most immunologists will disagree with Ramon's attempts to prove that Ehrlich's views on toxins and toxoids were wrong. The last 38 pages of the book are formed by a list of Ramon's 622 scientific papers, most of them dealing with antitoxins, the neutralization and flocculation of toxins by antitoxins, and the use of stimulants and adjuvants in immunization. This interesting book is recommended to all those who desire to become acquainted with immunization against toxins and, particularly, with the action of anatoxins.

FELIX HAUROWITZ

BACTERIAL POLYSACCHARIDES—*Their Chemical and Immunological Aspects.*

By Martin Burger. Charles C. Thomas, Springfield, Illinois. $6.00. xii + 272 pp. 1950.

This book is concerned with those polysaccharides extractable from pathogenic bacteria which are of importance in immunological research, therapy, and typing. It is organized into chapters each dealing with a group of bacteria, such as the pneumococci, streptococci, *Neisseria*, anthrax, *Salmonella*, *Shigella*, coliforms, *Brucella*, micrococci, mycobacteria, and others. Each chapter gives a prosaic narrative of the extraction, isolation, and chemical analysis of the antigenic polysaccharide components, followed by their uses in diagnosis, therapy, and prophylaxis. An appendix of about 30 pages includes summaries of preparative methods. These point to the original texts, from which they are abstracted, and to which direct reference will probably be made by workers intending to use the methods, especially for those preparations which do not now have routine diagnostic value.

Several limitations, including its discursive style, may make this book less useful than it might be for the advanced student, research worker, or general reader. One chapter rather tangentially narrates Dubos' discovery of gramicidin, but confuses enzymatic adaptation with selective microbial enrichment (p. 40). Recent studies on the biosynthesis of polysaccharides are outside the scope of the book. The statement (p. 294) that a 1945 paper on *Salmonella* "for the first time, shows a possible means for classifying the species in this group of organisms" expresses an overemphasis on the biochemical approach not likely to be endorsed by taxonomists who have long been working on the serological classification of *Salmonella*. The main question, however, is whether some work such as this, but one which dealt more broadly with specific antigenic substances regardless of chemical nature would not be much more useful. However, until such a work is published, or existing monographs are brought up to date, the present book offers an assemblage of details which, together with its comprehensive, though not exhaustive, citations, may make it of considerable use to students and workers in diagnostic serology.

JOSHUA LEDERBERG

MICROBIOLOGY

PRINCIPLES AND PRACTICE OF BACTERIOLOGY. *Third Edition.*

By Arthur H. Bryan and Charles G. Bryan. Barnes & Noble, New York. $1.50. xii + 410 pp.; ill. 1950.

This small but useful book gives a large amount of condensed information on a wide range of topics in elementary bacteriology and immunology. The style is simple and direct, with very little general discussion, so that the book verges a trifle toward being a "cram" book. If such was the intention, a very excellent and popular job has been done, as indicated by frequent reprintings. However, the present 1950 reprinting is based upon the third edition of 1942, so that certain vital developments of the last 10 years seem to be missing. Thus there is no mention of penicillin and streptomycin, at least not in the index.

WALTER C. TOBIE

LABORATORY MANUAL FOR GENERAL BACTERIOLOGY.

By A. R. Grismer. Burgess Publishing Co., Minneapolis. $1.75 (paper). ii + 85 pp.; text ill. 1949.

This beginning manual comprises 13 experiments, apparently expected to require 4 hours each, and is mimeoprinted on one side of the paper. It has a spiral binder. It is issued from the South Dakota State College, Brookings, S. D. The material is generally sound for an introductory course, which can necessarily stress only general principles. Each exercise is followed by a set of questions, with blank spaces for inserting answers. One questionable feature, under General Instructions, is the suggested use of mercuric chloride solution as a general laboratory disinfectant. The use of some true germicide rather than a bacteriostatic agent might seem preferable.

WALTER C. TOBIE

GENERAL BACTERIOLOGY LABORATORY EXERCISES.

By Michael J. Pelczar, Jr. Burgess Publishing Co., Minneapolis. $1.75 (paper). ix + 58 pp.; ill. 1949.

This mimeoprinted manual with a spiral binder is intended for "a course in elementary bacteriology for college students, regardless of their background or field of specialization," and is issued from the University of Maryland. There are 42 exercises, "based on a one

semester course with two laboratory periods per week," and covering a wide range of aspects. Each exercise is followed by a sheet on which the results are to be recorded. Apparently it is intended that these sheets shall be torn out of the manual and passed in for correction, instead of the student's turning in a notebook or the manual itself. The manual will merit the attention of instructors who prefer this method of reporting laboratory results.

WALTER C. TOBIE

EXPERIMENTS IN GENERAL BACTERIOLOGY. *Second Edition.*

By W. B. Sarles, J. B. Wilson, S. G. Knight, E. M. Foster, and W. C. Frazier. Burgess Publishing Co., Minneapolis. $1.50 (paper). v + 77 pp.; ill. 1949.

This mimeoprinted manual with spiral binder appears to be for a first laboratory course in microbiology. It is issued from the Department of Agricultural Bacteriology of the University of Wisconsin. Some 27 experiments are given on the characteristics of microorganism, and their presence and action in soil, water, sewage, and foods. Three experiments in pathogenic bacteriology are included. The experiment with the avian strain of the tubercle bacillus is unlikely to cause trouble. The desirability of including an experiment with *Bacillus anthracis* in a beginning course may well be questioned. Otherwise, the experiments seem well adapted to their purpose.

WALTER C. TOBIE

ANNUAL REVIEW OF MICROBIOLOGY. *Vol. IV.*

Edited by Charles E. Clifton, with Sidney Raffel and H. Albert Barker. Annual Reviews, Stanford, Cal. $6.00. x + 383 pp. 1950.

To review a series of reviews encompassing 358 pages is an impossibility, but the scope of this volume can be indicated by the subjects covered: Electron Microscopy of Microorganisms and Viruses (J. Hillier); Bacteriophages (T. F. Anderson); Constituents of Mycobacteria (F. B. Seibert); Mutualisms in Protozoa (R. E. Hungate); Bacterial Metabolism (L. O. Krampitz); Newer Antibiotics (W. E. Herrell); Genetics of Microorganisms (E. L. Tatum and D. D. Perkins); Genetics of Viruses (F. B. Gordon); Current Trends of Experimental Research on the Aquatic Phycomycetes (R. Emerson); Development of Bacterial Resistance to Chemotherapeutic Agents (C. P. Miller and M. Bohnhoff); Chemotherapy of Virus and Rickettsial Infections (M. D. Eaton); Antibiosis in Relation to Plant Diseases (R. Weindling); Immunological Reactions in Viral Diseases (H. Koprowski); Immunology of the Human Mycoses (A. M. Kligman and E. D. DeLamater); Tularemia (L. Foshay); Brucellosis (M. R. Castaneda); and Influence of Nutrition in Experimental Infection (P. F. Clark). This volume represents another worthy example of the valuable contribution which the various *Annual Reviews* are making to the authoritative compilation of recent literature and to the integration of research subjects. Each of the 17 reviews in this volume is an aid to the specialist in the particular field reviewed as well as to the specialist in other fields of biology. The job of perusing the immense literature of our day, an impossibility for an individual, has been accomplished here by leading investigators in the specific subjects, which has resulted not in a mere compilation and summation of published work, but in most instances in a critical and thought-provoking assessment of progress. The amount of material covered is indicated by the fact that 2588 references, including the Bible, King James Version, are cited. The only suggestion which the reviewer would like to make is that more uniformity should be achieved in the style of tabulation of the literature cited. Some literature lists are given in alphabetic order (the preferable arrangement), whereas others are arranged numerically according to the order in which the paper is cited in the particular review.

WERNER BRAUN

HEALTH AND DISEASE

ESSENTIALS OF MATERIA MEDICA, PHARMACOLOGY AND THERAPEUTICS. *Fifth Edition.*

By R. H. Micks. J. & A. Churchill, London. 21s net. x + 438 pp. 1950.

The writer of this textbook had two aims in mind, to teach the junior student the principles of drug therapy and to provide the senior student and the physician with guidance in the administration of drugs. The book has included most of the new drugs of importance that had appeared on the medical scene up to the end of 1949.

For American students and physicians the British names will be confusing. Unfortunately, many drugs are known by several names. Preference has been given to British Pharmacopeial names in this text, although U. S. Pharmacopeial names are frequently included.

The outline of the text follows the conventional method of classification, according to site of drug action, narcotics, analgesics, convulsants, etc. The author employs the term "disintegration" of the central nervous system repeatedly in discussing the action of anesthetics and narcotic drugs. Thus, anesthesia becomes a "reversible disintegration of the central nervous system." The usual term "depression" is perhaps more descriptive. The presence of peroxides in ether makes the vapors so irritating that it cannot be inhaled, according to the authors' statement (p. 54). It has

been fairly well established that concentrations of peroxides far below this level will be harmful to the patient when ether is used as an anesthetic agent. Theobroma oil is incorrectly called oil of theobromine (p. 109). Contrary to the authors' statement (p. 351), the exact chemical composition of streptomycin is known. A severe criticism of the text might be the scant reference to penicillin in syphilotherapy, for the replacement of the arsenicals by penicillin in the treatment of syphilis has been one of the major revolutions in medical practice in recent years.

On the whole, very recent drugs are adequately presented in the text. Thus, one finds cortisone and cortical extracts, vitamin B_{12}, the antihistaminics, tetraethylammonium compounds, the new local anesthetics, and the hydantoinates compared with older therapeutic agents.

With the possible exception of teachers and research workers in the field of pharmacology, the volume has little to offer to students in the United States that is not already adequately considered in greater detail by American textbooks on this subject.

C. JELLEFF CARR

HUMAN PATHOLOGY. *Seventh Edition.*

By Howard T. Karsner. J. B. Lippincott Co., Philadelphia, London, and Montreal. $12.00. xxiv + 927 pp. + 14 pl.; text ill. 1950.

This popular textbook of pathology, first published in 1926, is now in its 7th edition. Although its general format remains the same, it has been extensively revised. There are 2 new chapters covering diseases of the eye and skin. The chapter on infectious diseases has been rewritten and enlarged to include diseases which have recently come into prominence; and that on diseases of the liver has also been rewritten in the light of recent studies of this organ. The index has been improved and the bibliography brought up to date. There are 241 new illustrations. This textbook of pathology should continue to be popular with medical students and graduate physicians.

ELLA H. OPPENHEIMER

BRUCELLOSIS (*Undulant Fever*)—*Clinical and Subclinical. Second Edition, revised and enlarged.*

By Harold J. Harris, with the assistance of Blanche L. Stevenson; foreword by Walter M. Simpson. Paul B. Hoeber, New York. $10.00. xxvi + 617 pp. + 2 plates; text ill. 1950.

Probably no animal disease makes a stronger imprint on human welfare today than brucellosis. In the 2nd edition of his well known textbook, Harris brings to the general practitioner an excellent clinical reference. The arrangement of material in the book follows in general the method employed in the 1st edition. While there are certain shortcomings in the procedures recommended for the management of acute and chronic infections, the monograph is authoritative and is highly recommended.

MALCOLM H. SOULE

STILLBIRTHS. *Their Epidemiology and Social Significance.*

By Ian Sutherland, with a foreword by John A. Ryle. Oxford University Press, London, New York, and Toronto (printed in Great Britain). $1.50 (paper) xii + 95 pp. 1950.

This reviewer is professionally obliged to spend a good part of his time working with incomplete or otherwise defective statistics of many countries. After that diet, it is a thorough pleasure to be confronted with this material from England and Wales, with figures that mean what they say and that can be used "as is." Sutherland has accomplished—as usual—a thorough job of scholarly analysis, culminating in an elaborate study of multiple and partial correlations, based on county and county borough data. The stillbirth ratio was found significantly associated with poorly paid work, infant mortality at ages 3–12 months, and unemployment, but not with overcrowding of dwellings. The author's conclusion from these and other findings is that "the best practical policy . . . appears to be to maintain the equitable distribution of essential foods, to ensure that sound education in nutrition reaches the poorest section of the community . . . and to improve the medical and obstetrical facilities available to expectant mothers." A saving of about 3,000 lives per year is considered to be reasonable target for England and Wales.

C. TIETZE

THE MANAGEMENT OF THE PATIENT WITH SEVERE BRONCHIAL ASTHMA. *American Lecture Series, No. 76. A Monograph in American Lectures in Chest Diseases.*

By Maurice S. Segal. Charles C. Thomas, Springfield, Ill. $3.50. 158 pp. 1950.

This is an excellent monograph which should be read by the physician and others interested in the problem of bronchial asthma. The author does not concern himself with the etiology, diagnosis, nor specific immunologic treatment of this condition. The discussion of skin-testing procedures, elimination measures, dosage tables, and diets is left in large measure to other authors. The author confines himself to that very important question which deals with the therapeutic management of the individual severely ill with bronchial asthma, either acute or chronic. The devastating intractable

attack, the so called status asthmaticus, is given considerable attention.

Segal discusses adequately and clearly the effects of the various drugs used in asthma, including those given by injection, orally, rectally, or in the form of aerosols, with recommended dosages for each drug. He provides a very considerable amount of information regarding the inhibiting or protecting effect of drugs on bronchospasm. This information he has obtained from his unique and interesting "protection studies." Realizing the difficulty in evaluating clinically the drugs used in the treatment of bronchospasm, he developed a method of producing dyspnoea and bronchospasm at will by the administration to sensitive subjects of histamine or acetyl-beta-methyl choline (Mecholyl) and then measuring the effect on vital capacity before, and at varying intervals after, the administration of the drug under investigation. Such studies were made with anticholinergic drugs (atropine, scopolamine, and bellafoline); and with the sympathomimetic amine drugs, such as epinephrine, vaponephrin, isuprel, neosynephrin, and ephedrin. Also studied in this way were aminophyllin and the antihistaminic drugs. The pituitary adrenocorticotrophic hormone (ACTH) is being similarly studied, but the manuscript for this volume had gone to press before much data could be collected by the author.

The sedative drugs which are useful and safe are discussed as well as supportive therapy with saline or drug infusions. The therapeutic use of the gases helium and oxygen, and the techniques of antibiotic aerosol therapy are adequately presented, as well as the question of the evacuation of bronchial secretion by therapeutic or by mechanical means (bronchoscopic aspiration, etc.).

Segal is to be congratulated upon having collected in this volume much information upon the use in the asthmatic attack of drugs and devices both old and new, and upon having presented it in such a authoritative and understandable way.

W. C. SPAIN

AMERICA'S HEALTH. *A Report to the Nation.*
By The National Health Assembly. Harper & Bros., New York. $4.50. xvi + 395 pp. 1949.

With the aim of developing a 10-year plan for expanding the health resources and raising the general standards of health in the United States, the Federal Security Administrator called into session in May, 1948, a National Health Assembly, comprising some 800 representatives of the country's leading medical, health, and welfare organizations. The deliberations and recommendations of the 14 sections of the Assembly have been brought together in this volume for the enlightenment not only of the professional groups concerned with health, but of the general public as well.

Every aspect of medical care, health, and sanitation has been analyzed here from the standpoint of our present supply of personnel, services, and facilities, in relation to the minimum requirements for the maintenance of a healthy population. Where critical needs have been found, practical suggestions have been made for improvement.

For administrators, as well as general workers in the fields of public health and welfare, this volume will provide a wealth of material for thought and action.

B. AUBREY SCHNEIDER

MENTAL HYGIENE IN PUBLIC HEALTH. *McGraw-Hill Series in Health Science.*
By Paul V. Lemkau. McGraw-Hill Book Co., New York, Toronto, and London. $4.50. xiv + 396 pp.; ill. 1949.

Lemkau's book is a sound, fundamental contribution in an inchoate field. The early chapters on the place of mental hygiene in public health are clear and careful definitions of terms and working relationships. He defines the function of public health programs and degrees of responsibility by quoting Mustard, as follows: "A health problem becomes a public health responsibility if or when it is of such a character or extent as to be amenable to solution only through systematized social action." He outlines the areas of emotional disorder that can be reached by public health programs, "prevention of mental illness by a contribution to the mental health of the population and by the prevention of major illnesses through the early treatment of cases." And then he develops methods of achieving the synthesis. "The first basic method . . . is to approach the public for the purpose of getting it to act some way. . . . Public health has developed an organization for achieving relatively uniform activity at the level of contact with the public. . . . The most effective type of educational material appears to be that directed toward relieving parents of anxieties concerning child raising and toward solidifying and making more satisfying the child-parent relationship." The short section establishing this case impresses one as a sensible approach to community health needs and service possibilities.

Having determined logically that health department personnel will carry the burden of mental hygiene services in most communities, Lemkau feels that basic information on what a "normal" development pattern really is should be part of the equipment of health department personnel. He then devotes the greater part of the book to a discussion of the development of the individual. In this approach, Lemkau has steered carefully among etiological schools. His discussions

are averages of psychiatric thinking about development and emotional growth patterns.

This book makes two highly important contributions: it establishes mental hygiene programs in sensible perspective as public health opportunities, and it offers to public health workers a useful guide for their work in this field.

GEORGE A. SILVER

HEALTH INSTRUCTION YEARBOOK 1949.

Compiled by Oliver E. Byrd; foreword by Charles E. Smith. Stanford University Press, Stanford; Geoffrey Cumberlege, Oxford University Press, London. $3.50. x + 276 pp. 1949.

A wealth of information is contained in this reference book. It is composed of condensations of 255 articles, from 80 periodicals or reports, which were originally published between the middle of 1948 and the middle of 1949. The condensations are grouped into 21 chapters on the various fields or aspects of public health, the first chapter being Health as a Social Accomplishment. The last two chapters are, appropriately, on International Health, and Trends and Possibilities. Each chapter is prefaced by a brief, informative introduction. There are a bibliography, a list of sources, and an author index to facilitate use of the volume.

HARRIETTE D. VERA

PNEUMOCONIOSIS. *Beryllium; Bauxite Fumes; Compensation. Leroy U. Gardner Memorial Volume. Sixth Saranac Symposium.*

Edited by Arthur J. Vorwald, with the collaboration of Manfred Bowditch, Thomas M. Durkan, and Theodore C. Waters. Paul B. Hoeber, Medical Book Department of Harper & Bros., New York. $7.50. xii + 659 pp. + 4 plates; text ill. 1950.

The papers presented at the sixth symposium on pneumoconiosis sponsored by the Saranac Laboratory and the Trudeau Foundation comprise this book. The volume is divided into seven parts. Five of these are devoted to this relatively new occupational disease associated with exposure to beryllium and its compounds. The original papers presented at the Symposium in 1947 have been brought up to date by the inclusion of a bibliography through January 1, 1950. There are 684 references. Part VI is concerned with Shaver's disease. This disease has been described in workers engaged in the processing of bauxite for the manufacture of corundum. Part VII is devoted to a discussion of the status of compensation for occupational disease. The subject is considered from the standpoint of the medical practitioner, the administrators of compensation laws, insurance companies, and plant management.

The history and industrial aspects of the beryllium problem are reviewed. Apparently beryllium produces a unique disease both in its acute and chronic or delayed character. Toxicity studies on beryllium in connection with atomic energy production and experimental beryllium poisoning in animals are reviewed most comprehensively. Future developments in this field appear to await the discovery of more sensitive analytical methods for beryllium.

The toxicologic aspects of this study are exceedingly interesting. Like the uranium toxicology studies published recently, we find that new industrial hazards are evolved as the result of the sudden introduction into large-scale manufacture of compounds heretofore little known. A more idealistic approach would have been the study of the toxicology of "new" metals before they were used in industry, a course that is prescribed by law in the food and drug industries. Apparently we have not reached this state with respect to mechanical industrial processes.

The volume will be especially useful to toxicologists and those concerned with industrial hygiene. As a model case of a concerted attack on a new and baffling disease, the review is to be recommended to all medical scientists.

C. JELLEFF CARR

DE PRIMAIRE ATYPISCHE PNEUMONIEËN VAN ONBEKENDE OORSPRONG.

By Th. Van Erp. E. J. Brill, Leiden. 6.00 guilders (paper). vi + 124 pp. + 8 plates + 1 chart. 1947.

A study of more than 100 cases of an atypical pneumonia occurring as an epidemic in Curacao, and refractory to sulfa drugs but amenable to penicillin therapy.

PSYCHOLOGY AND ANIMAL BEHAVIOR

ANIMALS AND THEIR BEHAVIOUR. *Merlin Books. By Maurice Burton. Longmans, Green & Co., New York; Edward Arnold & Co., London.* 60 cents. 144 pp. 1950.

Although animal behavior is a most complex subject to deal with, some of its general features have nevertheless been condensed in this highly readable guide to the subject. Intended solely for the layman, the main basic generalizations are conveyed to the reader in a strictly non-technical style which avoids any specialized lingo. For a quick insight into certain phases of the field, this little book will be useful. Topics covered include the effects of aggregations on behavior, migrations and homing, hibernation, play, courtship, and

camouflage. The writer repeatedly points out how interpretations of animal activities are difficult to make and how easy it is to form anthropomorphic deductions. Repeated statements should convince the reader of our ignorance concerning many behavioral patterns in animals and that only continuous patient observations will unravel some of these mysteries. Illustrations demonstrate some of the varied animal activities discussed.

HENRI C. SEIBERT

THE ORGANIZATION OF BEHAVIOR. *A Neuropsychological Theory.*

By D. O. Hebb. John Wiley & Sons, New York; Chapman & Hall, London. $4.00. xx + 335 pp.; ill. 1949.

Here is one of the most important books in modern-day psychology. In a highly competent work, Hebb has brought together diverse facts and ideas from neurophysiology and clinical, animal, and experimental psychology to form a general theory of behavior. Perhaps the great merit of Hebb's approach is that it is a fresh return to the basic experimental facts, at a time when most of the theorizing in psychology either stems from the rather narrowly conceived behavioristic or gestalt schools of thought, or else is highly speculative.

Hebb starts out with the question why gross damage to the brain of an adult man (frontal lobectomy or hemidecortication) often has no measurable effect on his intelligence, especially since similar injury in infancy leads to severe intellectual impairment. Neither behavioristic nor gestalt theory can account for this finding. Behaviorism fails because it postulates a simple telephone-switchboard type of connections in the central nervous system. The connections are supposed to be built up in experience and must not be broken by brain damage if function is to persist. Gestalt theory is equally weak, for it assumes that the nervous system is organized into functional fields that are given at birth or developed in maturation. With such assumptions, early and late injuries to the nervous system should have the same devastating effects on intelligence.

The first step in Hebb's theory, then, is to make different assumptions about how the nervous system functions, in order to account for these as well as many other phenomena of behavior. Taking the best information that neurophysiology has to offer for his purpose, Hebb assumes first that there must be fairly large numbers of neurons involved in any functional connection in the nervous system. Then he postulates that in the course of learning or experience, these "cell assemblies" may grow and form new functional connections so that new stimuli may "fire" the assembly. Because experience or learning is relatively permanent, Hebb suggests that the development of the cell assembly may represent an actual outgrowth of axonal end-feet. But the important thing is that in the course of learning some kind of persistent neuronal facilitation occurs which permits readier firing of the cell assembly.

As the cell assembly develops, it acquires new properties. Not only will new stimuli arouse it (*learning* or *association*), but also the cell assembly may be aroused, in the absence of sensory stimuli, by activity in other parts of the central nervous system which have become connected with it (*ideas* or *images*). In fact, cell assemblies may fire each other in complex chains or "phase sequences," as Hebb calls them (*thinking*). In some cases, such central activity may serve only to facilitate the firing of the cell assembly by sensory stimuli (*attitude* or *attention*). In still other cases, as we gain experience in seeing an object in many different positions, we develop the capacity to perceive it as the same object even though the stimulation provided by the various aspects of the object is different (*perceptual constancy*). In this case, the cell assembly develops until all the different kinds of stimulation afforded by the object can fire it. As a matter of fact, after sufficient experience, we no longer have to be stimulated by the whole object to have the assembly aroused and to perceive correctly (*closure*).

Coming now to the crucial evidence bearing on his theory, Hebb points out that early learning, especially in primates, is very slow. Chimpanzees reared in the dark take inordinately long to learn simple form discriminations. Blind humans who regain vision late in life and see for the first time are likewise extremely slow in learning to identify geometrical forms correctly. And of course, the learning of infants is quite slow. These findings fit in with Hebb's idea that the initial development of functional cell assemblies is a slow process dependent upon repeated sensory experience. Once the assemblies have been developed, as in the case of the normal adult, new learning is only a matter of organizing them into new phase sequences of assemblies, and therefore is very rapid.

Early learning is also very important once it takes place, for it determines the kinds of cell assemblies which will be developed and thus determines the kinds of phase sequences—the kinds of new learning or thinking—that can be developed. In support of this point, Hebb brings together numerous lines of evidence showing the importance of early life experience on later behavior.

With these distinctions between early and late learning, it is easy to see how different can be the effects of early and late brain damage. Early damage has severe effects because a relatively small injury can prevent the first development of cell assemblies on which later learning, problem solution, intelligence,

etc., must depend. The same damage late in life, when cell assemblies have greatly grown, may have little effect on important functional connections. Enough of any cell assembly may survive to permit good function, and with all the connections developed in experience, it is not likely that any assembly would be completely cut off from peripheral or central stimulation. Hebb does not doubt that there are functional losses following adult brain injuries, but they are not detected by the usual tests of intelligence, which mainly measure what has been gained in experience—that is, whether certain cell assemblies can be aroused at all.

Following the basic development of his theory, Hebb goes on to use it in a discussion of many other basic problems in psychology: insight, instinct, pain, hunger, sleep, emotion, neurosis, psychosis, and many others. As he takes up these various topics, the value of his theory becomes quite apparent. For one thing, Hebb can account for most of the main aspects of these problems within his theoretical framework. But even more important, his fresh point of view makes it both necessary and feasible to take into account a good deal of long-neglected experimental work which conventional theories have been unable and unwilling to handle. Finally, Hebb has been careful to separate fact and theory in the development of his viewpoint. He clearly points the way to the experiments which have to be done by stating his ideas in the form of experimentally testable hypotheses.

Here is a stimulating book that reviews many of the basic facts of psychology and ties them together into a broad theoretical framework. Much of what Hebb says obviously needs testing, and undoubtedly the theory will have to be revised many times. But even as it stands, it is an outstanding contribution to the science of behavior.

ELIOT STELLAR

GESTALT PSYCHOLOGY. *Its Nature and Significance. By David Katz. Translated by Robert Tyson. Ronald Press Co., New York.* $3.00. x + 175 pp. 1950.

The theoretical framework of gestalt psychology has had a considerable influence on the development of psychology as a science. In essence, the gestalt point of view emphasizes the primary nature of organization in mental life and behavior, and so contrasts with the essentially atomistic approach of behavioristic psychology. Although this influence has been felt most strongly in researches on perception, it has nonetheless contributed something to nearly all the major research areas of psychology.

Katz's little book is essentially a primer—a description of gestalt theory, its nature, and its significance in psychology. It is a translation of the second German (1948) edition of the book, which first appeared in 1942, in Swedish. The author is eminently qualified to write such a book, since he is undoubtedly one of the world's leading exponents of this "school" of psychology. The treatment in the book is clear and interesting. Psychologists and general readers who want to acquaint themselves with this point of view will find the book rewarding.

A. CHAPANIS

PSYCHOLOGY—*Principles and Applications. By Marian East Madigan. C. V. Mosby Co., St. Louis.* $4.25. 403 pp.; ill. 1950.

Here is a treatment of general psychology for the student nurse. The topics familiar in the general introductory course are discussed in the usual manner, with recurrent emphasis on their relations to the typical tasks and interests of the nurse. A single section is devoted to Psychology and the Student Nurse.

The overall tone of the book is impersonally didactic, with wide excursions into moral exhortation and a more inspirational key. The tendency in the direction of oversimplification is rather too strong; e.g., "Sick people are really dependent people looking for temporary security" (p. 369). The value of much of the advice so freely dispensed may also be questioned. For example:

> "If you wish to eliminate your undesirable personal characteristics, you must first know what they are. To find out, have a few of your best friends list those traits which they admire most and least in you. If your 'best' friends will not tell you, another source is the comments an irritated or angry room-mate hands out. Truth often evolves under exasperation" (p. 244).

The rather loose organization of this work, as well as its vacillation between the impersonal and the sentimental, should be reviewed by any instructor who is considering its use as a textbook.

ERLING ENG

COLOR PSYCHOLOGY AND COLOR THERAPY. *A Factual Study of the Influence of Color on Human Life. By Faber Birren. McGraw-Hill Book Co., New York, Toronto, and London.* $4.50. x + 284 pp. + 16 plates; text ill. 1950.

Faber Birren's new book is a survey of the historical and contemporary uses of color. In the preface and text, Birren indicates that he has written his book with the medical profession in mind, as an attempt to combat what he feels is an unjust prejudice against the use of color in medical practice. To this end Birren has reviewed the history of the use of color by quacks and mystics as well as by reputable investigators, sorting out and presenting the conclusions which he feels are tenable and useful for the physician. Also, he has

devoted a large portion of the book to certain non-medical uses of color and to some elementary physiology and psychology of vision. Unfortunately, the style is more suited to the amusement of a lay reader than to the persuasion of a skeptic. Conclusions and opinions are quoted, with no more than a hint as to the data upon which they are based, and in some cases important negative evidence is omitted in the endeavor to present proof of a "fact" (e.g., Birren does not mention the significant evidence against Kravkow's claim of intersensory effects on vision).

The book is best in the short chapter on Functional Color, where Birren's wide experience as a color engineer adds authority and interest. In view of the author's reputation and experience, the rest of the book is something of a disappointment.

HOWARD D. BAKER

THE MATHEMATICAL THEORY OF COMMUNICATION. *By Claude E. Shannon and Warren Weaver. University of Illinois Press, Urbana.* $2.50. vii + 117 pp. 1949.

The first and major section of this book (written by Shannon) presents a high-powered mathematical theory of communication. The work originated in the study of telephone networks and of the transmission of messages in such networks under a variety of conditions. Thus, the theory first defines information in a mathematical way, relates this definition to the thermodynamicist's concept of entropy, and then discusses such things as redundancy, the coding of messages, and what happens to information when noise is introduced into communication networks.

At first glance, it might appear that this is primarily an engineering monograph with little or no application to human problems. Actually, the theory has some rather exciting implications for the study of certain human problems, particularly the study of language. These are discussed in the second part of the book (written primarily by Weaver), which is a non-mathematical explanation of the theory. Unfortunately, there is not enough of this kind of translation for the social scientist, who is seldom a mathematical specialist. Nonetheless, readers who are interested in language, communication, meaning, and related problems will find this monograph rewarding.

A. CHAPANIS

THE PSYCHOLOGY OF THE ELEMENTARY-SCHOOL CHILD. *By Lawrence A. Averill. Longmans, Green & Co., New York, London, and Toronto.* $4.00. xii + 459 pp.; ill. 1949.

This is a book intended to acquaint teachers and teachers-in-training in the elementary schools with the basic factors of child development. As the title implies, it is specifically oriented to elaborating the psychology of children between the ages of 6 and 12. The material is based on Averill's 30 years of teaching teachers to understand children. This experience has, no doubt, given the somewhat pedantic air to the book, an atmosphere enhanced by placing exercises outlined for the teacher at the beginning of each chapter and intended to focus her attention on specific child needs or child reactions that she can notice in her own classroom.

Averill covers a wide range of material, from a detailed description of the emotions of the school child, attitudes and habits, language and speech, basic concepts of learning, and processes of thinking, to a description of child guidance and the importance of early childhood training as it impinges on the child of school age. It is a quite complete book written for an unsophisticated, but intelligent audience. I think it will be of real value as required reading for the very group for whom the author first developed this organized presentation and for whom he has now brought it together in this volume.

HELEN ARTHUR

EMOTIONAL DISORDERS OF CHILDREN. *A Case of Child Psychiatry. By Gerald H. J. Pearson. W. W. Norton & Co., New York.* $5.00. 368 pp. 1949.

Pearson, who has had many years experience as a child-psychiatrist and as a child-analyst, has written a really dynamic clinical textbook about children and their emotional problems. He begins appropriately enough by describing in detail how to take a psychiatric history on a child. The child himself cannot give an anamnesis. So, in treating children, the psychiatrist must get the child's whole story from the parents and then, of course, put it together in terms of its bearing on the problem under consideration.

Pearson then takes up the diagnosis and classification of psychiatric problems in children. Since a symptom such as enuresis may be evidence of different emotional formations, diagnosis is an important first sep in setting up a sound therapeutic program. After laying the foundation for the clinical approach to child psychiatric problems, Pearson presents in the following 11 chapters discussions of the different kinds of emotional illness which occur in children. These, according to the author, are anxiety states, anxiety hysteria, conversion hysteria, psychosomatic reactions, obsessional neurosis, intellectual retardation, sexual perversions, character neursoses, and then the actual schizophrenic psychosis. The author's presentation of these clinical entities is accomplished in a most thorough and competent fashion. Using actual cases, he shows the problem, explains the emotional structure involved, and indicates

the course therapy must take. The book, however, is by no means just a collection of cases. The cases give excellent illustrative material from which the theoretical points can be developed convincingly and clearly. The cases provide the clinical thread which makes the book a creative, pragmatic text.

The style of writing is relaxed and simple, and the book is completely free of pedantry. It makes good reading. Pearson does not oversimplify the complicated emotional situations with which he deals, but conveys the idea that he knows thoroughly what he writes about and that there is a sound scientific and understandable way of thinking about children's psychiatric problems.

This book should serve to obviate the pernicious trend of thought which prevails in some circles that all one needs to do for problems of child behavior is to play with the child and be friendly, and the symptoms will then vanish forever. It takes child psychiatry out of the realm of "just be good to children" and also out of the realm of the pedantic mouthing of big words, and puts it where it belongs as an important medical specialty.

HELEN ARTHUR

SOME ASPECTS OF HOSTILITY IN YOUNG CHILDREN.
By Anneliese Friedsam Korner. Grune & Stratton, New York. $3.50. x + 194 pp. 1949.

This is another monograph in the long procession of psychological studies upon all sorts of groups to assess all varieties of emotional response. This type of research is probably important, since the effort to isolate psychological phenomena and to subject them to detailed scrutiny is the only way in which our many assumptions regarding personality and emotions can be verified or challenged. As an example of this genre of study, Mrs. Korner's is an intelligently executed investigation of a major emotional area. Her conclusions are carefully limited to the scope of her material but carry implications into a much wider realm.

The subjects in this study were 20 boys and girls, aged 4 to 6, in a day nursery run for children from working-class families. The children's expressions of hostility in both fantasy (play) situations and in real life were recorded, and these data were analyzed both qualitatively and quantitatively. The author verifies, in this sample group, the fact that aggressive fantasies are inherent in a small child's play. However, no evidence was found that the child's real-life aggressiveness can be ascertained from observing his play. There are different patterns of aggressive responses in children. It is not possible to determine a positive correlation between the child's overt expression of hostility in his environment in his play on the one hand, and his total personality adjustment as evaluated by neutral but trained observers on the other. There was no evidence, either, to support the thesis that the rejected child is the openly hostile child.

All in all, this monograph injects a healthy if minor question mark into the subject of hostility. Hostility is a basic emotion, and clinical workers of different schools have arrived at a number of theoretical assumptions regarding it. This study points up the fact that such theoretical dogma must be examined more critically in order to be pronounced scientifically sound.

HELEN ARTHUR

SAINTS, SINNERS AND PSYCHIATRY.
By Camilla M. Anderson. J. B. Lippincott Co., Philadelphia, London, and Montreal. $2.95. x + 206 pp. 1950.

The central concepts of this book are that anxiety of one sort or another is the basis of all unhappiness and of mental illness, and that this anxiety arises because of threats to the physical or psychological structure of the person. These threats may be fended off to avoid anxiety or guilt feelings by aggression, by withdrawal, or by conversion into physical symptoms. "The severity of the neurotic disability is determined not by the discrepancy between the assumptions of an individual and the actual reality situation, but rather by the discrepancy between his assumptions and the assumptions of the culture with which he tries to identify himself. The goal of all behavior is to forestall anxiety or to deal with it if it arises." Dr. Anderson is a good writer and presents her material clearly and well. Cases are used to illustrate points, and, with a few exceptions, appear well selected.

To the scientist, the problem presented by the type of argument in this book is the ancient one of how to deal with hypothesis lacking controlled data. Psychodynamics is a fascinating field and one that is of basic importance in science. This can be granted freely, and it can even be granted that the evidence of the case study constitutes valuable data. To point out that it is not data for a "critical" experiment does not decry the production of hypotheses by this method. At the same time, it does require that hypothesis be labeled as such and not as fact, however useful the hypothesis may prove in therapy or for other purposes. The question, impossible to answer by methods now available, whether all cases with these factors thus weighted and with these capacities so organized will react the same, is a justifiable one on scientific grounds. Such books as this must be judged according to how well they approach the solution of the basic question. In spite of many contradictions and the use of data on both sides of a question when convenient, this book does contribute usefully to hypothesis, even though it ap-

pears to be considerably oversimplified and to avoid many complexities in the field.

The author assumes that all psychological behavior is for the purpose of allaying anxiety. This statement along with the assumption that anxiety is not a good thing (the discussion of healthy causation for behavior appears very weak) should logically lead to the conclusion that mental health is the absence of psychological activity. This is a bald criticism of one facet of the study, but it indicates some of the logical problems encountered in most works of this sort.

The volume is beautifully printed and edited, and, to repeat, the style is readable and clear.

PAUL V. LEMKAU

RELIGION AND THE CURE OF SOULS IN JUNG'S PSYCHOLOGY. *Bollingen Series XXI.*

By Hans Schaer, translated by R. F. C. Hull. Pantheon Books, New York. $3.50. iv + 221 pp. 1950.

The author of this book is a Protestant theologian and pastor whose own inner experience and professional tasks forced him to come to grips with certain discoveries and theories of modern psychology. In this endeavor he found the works of C. G. Jung so eminently helpful that he wrote down a resumé of the basic tenets and theories of this increasingly influential Swiss psychotherapist, mainly for the benefit of his brethren in theology. The author has succeeded so well that his book may be used as an introduction to "analytical psychology". The slight repetitiousness might then be a help rather than a handicap.

A final chapter deals with Jung's Significance in the Religious Situation of Today. It is a sort of inspired apology for the master's way of thinking, and I would advise those who know little of Jung's concepts to read it first. It will prepare the uninitiated—at least the uninitiated theologian—for the usual reaction to Jung's formulations on religion: namely, to be attracted, comforted, and shocked in turn. It is not possible even to enumerate here the many facts and interesting interpretations taken from Jung's writings, nor the author's own corroborations and additions. His comments are often of the type: don't be afraid, be fair and patient, Jung doesn't really mean it the way it sounds. The following few sentences may give some idea of what the book is about: Man has religious needs; religious experience is accessible to psychology; there is no fundamental distinction between religious processes and other psychic happenings; the psychology of the Unconscious—mainly the "collective" Unconscious—offers an interpretation of religious conversion and of myths; religion gives an expression to that which is present in the individual but not realized by him; religion is not only experience of the suprapersonal forces of the soul but consists also in adopting—psychically—an active attitude; religion thus offers the knowledge of new spiritual possibilities and with it the possibility of "individuation", i.e., of an extension of the personality beyond the Ego by recognizing and assimilating the Unconscious. If this is achieved, "the Self" as a new center of personality emerges. Religion therefore can be a way to spiritual healing and spiritual health.

Since even psychologists have begun to rediscover the importance of "inner experience" and to accord a major role to "values," it seems a fair guess that the position of religious experience and religious values will be re-examined and recognized as outstanding phenomena of man's psychic life. For this reason, psychologists and psychotherapists may read this book with almost as much benefit as theologians.

WALTER O. JAHRREISS

BODY AND MATURE BEHAVIOUR. *A Study of Anxiety, Sex, Gravitation and Learning.*

By M. Feldenkrais. International Universities Press, New York. $3.75. viii + 167 pp. 1949.

This is the substance of a series of lectures given by the author before the Association of Scientific Workers at Fairlie, Scotland, in 1943 and 1944. It is difficult to review. The author starts out with a commendable purpose of bringing the resolution of faulty habits of behavior, particularly faulty muscular patterns, into the overall psychological treatment of neuroses, with the object of promoting the general maturity of the individual. He points out that treatment of personality disorders has tended to split into two camps: one of modern dynamic theories, exemplified by psychoanalysis, which assumes that harmful habits of behavior resolve themselves automatically or the central psychological issues are resolved, and another, the camp exemplified by Yogi, which stresses voluntary efforts at relaxation and retraining of muscular patterns in the direct attempt to influence mental processes. Feldenkrais considers that a great number of people have been helped by the latter method as well as by the former. The book is essentially an effort to bridge the gap between these two viewpoints. The author shows by exhaustive summaries of embryology, neuroanatomy, and neurophysiology that the neuromuscular patterns of the human organism are markedly dependent on individual human experiences during the long term of development to an extent unknown in any other members of the animal kingdom. The pathologic or harmful muscular patterns are just as important an element in neurotic performance as are the mental mechanisms involved and act just as automatically as do the mental mechanisms. Feldenkrais argues that recognition of this fact and direct retraining along with psychological treatment could boost the proportion of successes in psychiatric treatment over

that attained by psychological methods alone. Freud's use of the couch, he holds, had more of a physiological effect by reducing the habitual patterns of anxiety evident in the neuromusculature than psychoanalysts have realized. The patient deprived of his usual habitual neuromuscular methods of expressing anxiety had to resort to memories, dreams, and so on, to produce it. The author concedes that cures of the habitual harmful neuromuscular and visceral patterns not infrequently occur in the course of psychological treatment alone, but he considers that this is no excuse for not making the direct attempt also.

The whole book is vaguely reminiscent of Lange's theory of the emotions; yet actually, in psychiatric practice and particularly in the treatment of psychosomatic conditions, the author's point of view can be amply illustrated. The book would have been much more valuable if Feldenkrais had given more concrete hints as to how specific problems can be tackled therapeutically. If he has such recommendations to make, a further publication would be most welcome. A considerable body of erudition is displayed in this volume, and psychiatrists who have been away from their basic studies for a long time will have considerable trouble in digesting the intricacies of neurophysiology and electrophysiology discussed. If my own attitude is anything like the usual one, the reader will find himself impatient for a statement concerning the significance of all this erudite knowledge to the practical problem of the consulting room.

WENDELL MUNCIE

ANXIETY IN PREGNANCY AND CHILDBIRTH. *A Psychosomatic Medicine Monograph.*

By Henriette R. Klein, Howard W. Potter, and Ruth B. Dyk. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $2.75. xii + 111 pp. 1950.

This monograph is a psychosomatic study of 27 young primiparous patients followed throughout the course of pregnancy and delivery in the clinic of the Long Island College Hospital. The patients were interviewed at intervals throughout the prenatal period and immediately after delivery. There was also a follow-up interview one to four months after delivery. From these interviews, both a psychiatric and a sociological evaluation was made of each patient. On the somatic side, the study concerned itself with physical symptoms throughout pregnancy and the type of labor which each of the patients had. The interview material gives some insight into the attitudes and anxieties that this type of clinic mother is likely to have, but any more important observations on the possible relation between emotional and somatic status were for all practical purposes non-existent. Although the mothers judged to be more "unstable" tended to have more bodily complaints during pregnancy, it is not clear to what extent these two kinds of judgments were really independent. To predict anything about the type of labor from the interview material turned out to be completely impossible.

ROBERT A. MCCLEARY

SOCIETY AND ITS CRIMINALS.

By Paul Reiwald; translated and edited by T. E. James. International Universities Press, New York. $4.50. xx + 315 pp. 1950.

In this book the distinguished jurist, Paul Reiwald, attempts to communicate something of the substance and value of the psychoanalytical approach to crime. Although he is hampered by what appears to be a poor and awkward translation—or, it may be, by a style that was originally dry and somewhat pedantic—he succeeds admirably in presenting to the serious student a compendious statement of that singular orientation which comes closest to providing answers in this complex and perplexing field. If, in places, his account is sparse and his evidence incomplete, he is not to be blamed. The fact is that the ground Reiwald is ploughing here has only seldom and spottily been turned; and, even after fifty years, it can still be considered virgin soil.

Reiwald is an excellent person for this kind of job and well equipped for the task. By training an advocate and by study a psychoanalytical thinker, he falls in the tradition of men like Sachs and Staub, who also tried to build a bridge between psychology and the law. Moreover, like these others, the present author is a man of culture and erudition, both of which stand him in good stead in his presentation of a discipline notoriously dependent upon a diversity of subjects. The scholarship that he brings to bear upon his work is particularly impressive and valuable for the American reader, since many of the sources mentioned are not available to us. One could wish, however, that the author's editors had been kinder to his book in this respect and had exercised some editorial art or concern for the reader by integrating the numerous important notes and references with the text, rather than so placing them that they break the continuity of the volume.

There is much about this book to recommend it even to a reader unfamiliar with psychoanalysis. For such a one, it will open up a new world in thought about crime and criminals. Particularly enlightening and provoking are the chapters entitled The Resistance of the Lawyer to Psychology, and The Judge and the Father. Perhaps even more fascinating and instructive is the lively fifth chapter, which deals with the psychology of the crime novel and ends with a psychoanalytic treatment of the criminologist Hans Gross, and his fictional counterpart, Sherlock Holmes.

It is too bad that a work on which there has obviously been lavished so much care and energy is fated to fall soundlessly into the bottomless pit of public and official apathy. The simple truth is that few of the people who should read this book will do so; and of these, most will resist its lessons and implications with that traditional but unreasoned rejection which psychoanalysis has always encountered. Yet, as Reiwald implies he believes, by his selection of a Goethean quotation for the motto of his book, "You must say it thrice."

ROBERT LINDNER

GROWING UP. *The Story of How We Become Alive, Are Born, and Grow Up. Second Edition, revised.*

By Karl de Schweinitz. Macmillan Co., New York. $1.75. 95 pp.; ill. 1950.

This is the second edition of the same book which was first published in 1928 and has been reprinted 22 times since then. In it, the author provides a simple, straightforward account of the processes of procreation, birth, and growth. It is written in such simple language that, according to the author, a child of seven can read the book for himself.

Material written for children is difficult for adults to evaluate. As a psychologist, my best guess is that this book should be eminently satisfactory for children. It should also be of immense help to that enormous group of parents who cannot, or will not, satisfy their children's normal curiosity about sex and birth in a sensible and intelligent manner.

A. CHAPANIS

CYBERNETICS—*Circular Causal, and Feedback Mechanisms in Biological and Social Systems. Transactions of the Sixth Conference, March 24-25, 1949.*

Edited by Heinz von Foerster. Josiah Macy, Jr. Foundation, New York. $3.50 (paper). 209 pp. 1950.

On March 24 and 25, 1949, twenty-three scientists from diverse fields—physiology, psychology, psychiatry, neurology, mathematics, engineering, and anthropology—met in New York for their sixth conference on cybernetics (circular, causal, and feedback mechanisms in biological and social systems). This volume contains the transactions of that conference—the first to be published. Papers were presented by John Stroud (a psychologist) on the psychological moment in perception, Lawrence S. Kubie (a psychiatrist) on neurotic potential and human adaptation, Heinz von Foerster (an electrical engineer) on a quantum theory of memory, and Norbert Wiener (a mathematician) on sensory prothesises. These rather formal presentations occupy less than half of the transactions, the bulk of which is made up of verbatim remarks and discussion by the participants.

Although there are several interesting things to be learned from these proceedings, the volume mostly supports two incidental conclusions. The first of these is that modern science has become so complex that specialists in one area can understand very little of what specialists in some other area have to say. This, incidentally, is one reason why the Macy Foundation sponsored these conferences. Perhaps later conferences may be able to achieve more effective interdisciplinary communication than this one.

The second conclusion which this publication supports very effectively is that non-directed oral discussion is highly diffuse, frequently obscure, redundant, and for the most part not worth recording. There are many words in these transactions, but, unfortunately, they lead to nothing definite and most of them don't say anything worth reading.

A. CHAPANIS

HUMAN BIOLOGY

SOCIAL STRUCTURE.

By George Peter Murdock. Macmillan Co., New York. $6.00. xx + 387 pp. 1949.

The author here describes, on the basis of data from 250 primitive tribes, the possible structures of familial, kin, and local groups. He deals with the inner logic of kinship terminology, and checks his hypotheses statistically.

Undoubtedly the most interesting part of the book is Murdock's discussion of the *evolution of social organization*. He is able to show that kinship systems are primarily not diffused, but arise and change locally. Change is usually initiated by a change in residence. Murdock differentiates 11 types of social organization. In an appendix he gives interesting material on the possible filiation of types in given societies. Chapters on the regulation of sex, incest taboos, and the "social law" of sexual choice conclude the book.

That the book is rather dull and full of truisms should not obscure the fact that it is definitely a positive contribution in a field where such contributions have become rare. The industry that has gone into the composition of the book is impressive. There are a number of new and excellent ideas. One would feel less inhibited in praising the book had the author not exhibited such extraordinary naiveté regarding the general importance of his contribution and the general validity of his method.

ERWIN H. ACKERKNECHT

HABITAT, ECONOMY AND SOCIETY. *A Geographical Introduction to Ethnology. Seventh Edition.*
By C. Daryll Forde. E. P. Dutton & Co., New York; Methuen & Co., London (printed in Great Britain). $4.50. xv + 500 pp.; ill. 1949.

This is the 7th edition of a book published first in 1934, much used as a textbook during the last 16 years, and still not superseded. In the first 8 chapters, 8 societies of so-called food-gatherers, living in the most differential geographical settings and using the most different techniques are described (Eskimo, Bushman, etc.). Five societies of cultivators (Yoruba, Hopi, etc.), and 4 of pastoral nomads (Masai, Tungus, etc.) follow. The concluding 6 analytical chapters do not force into any cheap scheme the complexity of the relations between the habitat, or the economics and societies developed within it.

ERWIN H. ACKERKNECHT

HUMAN ECOLOGY. *Prentice-Hall Sociology Series.*
By James A. Quinn. Prentice-Hall, New York. $5.00. xii + 561 pp.; ill. 1950.

For biologists, the term ecology still carries the significance given to it by Haeckel: "the investigation of the total relations of the animal both to its inorganic and to its organic environments; including, above all, its friendly and inimical relations with those animals and plants with which it comes directly or indirectly in contact." Webster's New International Dictionary subscribes to this view by making it the basis of its first and second meanings; but goes on to give a third: "*Sociol.* Study of the spatial distribution of a population in reference to material and social causes and effects."

After subscribing to the view that human ecology endeavors to view the relationships between the environment-function-organism triad as a whole, the author proceeds (on p. 12, rather than in the Preface) to limit the contents of the book to "only those parts that have special value for the sociological branch of this field." It is regrettable that a scientific term should be used differentially by different workers to indicate both a whole and a part; it is particularly regrettable that this should happen with a word which was intended to refer above all to the whole; and it is further regrettable that an author who professes to have seen the light should lapse so far as to apply it to a still further subdivision of the part.

In the ecology of man, account must obviously be taken of the sociological causes, interactions, and effects. To that end, this book may be profitable reading for those who, approaching human ecology from the biological side, seek to integrate their ideas with those of areal sociology. But potential readers must not expect to obtain from it a well-balanced view of human ecology.

DOUGLAS H. K. LEE

FARMER VICTORIOUS. *Money, Mart, and Mother Earth.*
By William J. Hale. Coward-McCann, New York. $3.00. xii + 241 pp. 1949.

The author, in a brief volume, has attempted to appraise the scientific phases of man's cultural development in terms of his economic and political advancement. He finds two factors which have led to every war of any consequence: the Babylonian system of finance, and international trade. The former, based on a false valuation of gold and silver, and demanding a fixed rate of interest for the moneylenders, has placed control of the nations' economies in the hands of bankers instead of farmers, who in reality control the only true wealth of nations. International trade, a problem of have and have-not, seeks to overcome the individual nation's deficiencies, and the banker's manipulations play a great role in determining distribution. The author sees a solution in a regrouping of the nations along a north-south axis to give to each coalition a wider climatic range, a withdrawal from the false gold and silver standard, with rates of interest fluctuating as the need for finances shift, and a development of the science of chemurgy to overcome the deficits upon which international trade feeds. Under this system the farmer would assume his rightful place in the hierarchial structure of each coalition of nations. This is, of course, a utopian ideal based on the brotherhood of man, and one whose attainment is impossible without complete objectiveness, trust, and good will. In an evolutionary sense, the experiment would be very interesting, for a species of human being would be confronted with a complete change of environment, necessitating a new set of adaptive mechanisms for survival. I speak of the politician, of course, but we can assume that his versatility is such as readily to meet the challenge.

C. P. SWANSON

TWO MOUNTAINS AND A RIVER.
By H. W. Tilman. Cambridge University Press, London and New York (printed in Great Britain). $3.75. xii + 233 pp. + 36 plates; text ill. 1950.

Some people climb mountains for information. Tilman climbs them for fun. He makes no pretense of scientific purpose—"to travel in the wrong direction is probably preferable to retracing one's steps." If in his travels he explores areas previously marked "unexplored" this is all to the good, but it is incidental. Tilman sees humor in deserts, ill-fitting boots, and communal spoons, and he comes close to seeing humor in

his arrest in Afghanistan on suspicion of being a spy. As an observer of nature, apart from human nature, he leaves much to be desired. As an interpreter of human customs in strange places he is, in an informal as well as comprehending fashion, excellent.

The book falls naturally into two parts. The first is an account of several unsuccessful attempts to find a route of Rakaposhi in June and July, 1947. Rakaposhi (25,550 ft.) is one of the many high peaks in the Gilgit region in northern Kashmir. Before the climbers separated, a trip was made up the previously unexplored Kukuay Glacier, north of Chalt. Then Tilman set out for the north, on the road to Kashgar.

Here begins the second and more interesting part of the book. The trip through western Sinkiang north to Kashgar and back develops into an odyssey of yaks, yorts, and yoghurt. On the return, visa-less Tilman crossed Wakhjer Pass into the Wakhan corridor of eastern Afghanistan, intending thence to cross the Hindu Kush to the south. His arrest as a suspected spy changed his plans. As he was marched westward from one police or army post to another, he became the first westerner in modern times to observe the peoples and the topography along the upper Oxus River. This unexpected, unpleasant, and enforced exploration provides a climax in a book that is throughout a record of high adventure in one of the least-visited regions in Asia.

GORDON ALEXANDER

THE ANTHROPOLOGY OF IRAQ. *Part I, Number 2: Lower Euphrates-Tigris Region. Anthropol. Ser., Field Mus. nat. Hist., Vol. 30, Part I, No. 2, Pub. 631.*

By Henry Field. Field Museum of Natural History, Chicago. $5.00 (paper). Pp. 225–426 + 80 plates; text ill. 1949.

This is one of the results of an expedition to the Near East, sent out by the great Chicago museum in 1934. It is essentially a record of the anthropological data and information collected by the author, as leader of that expedition, and his coworkers in the field. No attempt has been made here to fit the findings into the rapidly expanding general story of anthropology. The bulk of this report deals with the physical appearance of various tribes of people inhabiting the areas in the lower Euphrates-Tigris region, which range from arid desert to marshland in the alluvial plain at the head of the Persian Gulf. The bodily characters studied are limited to stature, sitting height, main dimensions of the head, and the standard descriptive features appertaining to eyes, nose, and hair. These data are listed in painstaking detail. Occasional additional data supply brief information regarding the teeth, general health, size of families, etc. Together with the very numerous photographs of front- and side-views of heads, all this new information forms a welcome contribution to that part of physical anthropology which is concerned primarily with the geographical distribution of the variations of recent man. The cultural anthropologist will be most interested in the able chapter by Lady Drower on the life and work of certain Arabs (of the Hor Al Hawiza) who inhabit the same general region.

A. H. SCHULTZ

EROTIC ASPECTS OF HINDU SCULPTURE.

By Lawrence E. Gichner. Published by the Author, 3405 Woodley Road, Washington, D. C. $5.00. 56 pp.; ill. 1949.

This slender volume, privately published for "scholars in the fields of anthropology and the social sciences . . . physicians, psychologists, and psychiatrists," is the work of a man outside the academic world. Technically an amateur, he has acquired by patient study over many years a thorough knowledge of his chosen field of interest, which is erotic art. Coupled with this knowledge are deep human understanding and unfailing tact. This enables him to present and discuss material that has been considered grossly obscene by the bigoted and that perplexes the student of comparative religion. What is the meaning of these sculptures, carved in profusion on the outside of many ancient Hindu temples? Some authorities believe that their purpose was to ward off the forces of evil from the building. Others see them as portraying the "good life" or as mere symbols pointing a way to obtain spiritual knowledge. Gichner surveys this gamut of opinions without forcing his own preference on the reader. The booklet is illustrated with 30 excellent photographs.

C. TIETZE

KING-DOCTOR OF ULITHI.

By Marshall Paul Wees and Francis Beauchesne Thornton. Macmillan Co., New York. $2.50. xii + 128 pp. + 8 plates. 1950.

In the midst of the Pacific war, the Navy sent Dr. Wees to Fasserai, a minute speck in a vast ocean, to rehabilitate a group of natives seriously afflicted with yaws. In contrast to the tremendous operations of war, the gesture was a small one. To the inhabitants of Fasserai, however, it meant their salvation. A termination to their suffering was accomplished, their church and school were restored, and their happiness was regained. To Dr. Wees, as he left the island after six months, king in the hearts of his people as well as in name and authority, the experience must have been an unforgettable and moving one. This is Wees' story, and as befits the man and the job, it is simply but magnificently told. It is also a tribute to the

Navy, and to you and to me who make such things possible.

C. P. SWANSON

BIOMETRY

AN INTRODUCTION TO PROBABILITY THEORY AND ITS APPLICATIONS. *Volume I.*

By William Feller. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. xii + 419 pp. 1950.

This is a rigorous treatment of probability theory. Starting with some rather simple problems of combinatorial analysis, the text then goes on to such advanced topics as infinite Markov chains, recurrent events, random walks, waiting time, trunking problems, and time-dependent stochastic processes. Especially noteworthy is the large number of illustrative problems and problems for the reader to solve (with answers provided in the rear of the book). This is much too difficult a textbook for most students in the biological sciences, but those who can handle this kind of material should find the book rewarding. In my opinion, this is the best and most adaptable book on probability theory which has ever reached my desk.

A. CHAPANIS

PROBABILITY AND THE WEIGHING OF EVIDENCE.

By I. J. Good. Charles Griffin & Co., London; Hafner Publishing Co., NewYork. $3.00. viii + 119 pp. 1950.

In this little monograph, the author presents a theory of probability which combines the usual mathematical content of probability with material not ordinarily considered in such treatises, namely, the state of mind of the person who is doing the reasoning or believing. The treatment is theoretical, highly mathematical, and somewhat philosophical. It is a book only for specialists—biometricians, statisticians, or mathematicians.

A. CHAPANIS

STATISTICAL DECISION FUNCTIONS.

By Abraham Wald. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. x + 179 pp. 1950.

In about fifty years "statistics" has advanced from the "calculation of averages" to a useful, but somewhat terrifying, methodology. It has developed through a series of fairly distinct stages which are associated with the names Galton, K. Pearson, R. A. Fisher, Neyman, and finally Wald. *Statistical Decision Functions* summarizes the late Professor Wald's contributions to the metatheory of statistics (1939–1950).

Wald's theory differs from the current statistical methodologies in that it is *pragmatic* and *sequential*. It involves the costs of observation and the costs of decisions, and it is based on the pragmatic principle of minimizing these costs (as opposed to the use of probability levels such as the 5 per cent level). It also allows us to determine sample size from what happens in the course of the experiment (as opposed to current use of fixed sample sizes).

The statistical theory developed by Wald might produce savings of fifty per cent or more in experimental costs and could also lead to more "realistic" decisions, especially in the fields of "applied science." However, few potential customers will be able to read this book; in fact, there are less than a hundred people in the world who *could* read, understand, and apply these abstract and advanced mathematical developments. It can only be hoped that some one of them will perform the arduous, unglamorous, but very necessary job of translating Waldian concepts into a methodology and language comprehensible to other scientists.

I. J. BROSS

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

THE ADVANCED ATLAS OF MODERN GEOGRAPHY. *New Series, First Edition.*

By John Bartholomew. Meiklejohn & Son, London; McGraw-Hill Book Co., New York and Toronto. $8.50. ii + 108 pp. + 46 pp. of general index; ill. 1950.

HAMMOND'S LIBRARY WORLD ATLAS.

C. S. Hammond & Co., New York. $5.00. 332 pp.; 178 maps; ill. 1950.

It is interesting to compare these 2 atlases, one British, the other American, and fairly similar in price. The decision between them is not difficult to make. In almost every respect the British product is far superior, particularly for the uses of a scientist. The Bartholomew plates are beautiful examples of cartography, and represent the physiographic features of the land and depths of the sea, as well as the political units, cities, and railroads recorded on the Hammond maps. The latter look crude and garishly colored in comparison. Moreover, the scale is frequently inadequate to show more than a minimum amount of information. The only exception to this is in the maps of the 48 individual states of the United States. These are much superior to the Hammond maps of foreign countries, and even show some orthographic detail. The American user will want to supplement the Bartholomew atlas with more abundant, large-scale maps of the U. S.

The Hammond atlas has nothing to compare with the Bartholomew atlas's geographical tables, map projections, and special maps of world physiographic features, time, climate, ocean currents, or distribution

of special crops, human races, population, languages, religions, etc. Both atlases are well indexed, the Bartholomew atlas with a newly devised system of coordinates related to the World Grid, based on Greenwich and the International Date Line, so that it gives instant information about local solar time. The coordinates for latitude are given in degrees and tenths of degrees, plus or minus, from the Equator. This system, once one has become accustomed to it, has great value.

The Hammond Atlas has an extensive Illustrated Gazetteer. It is a question whether the space and the expense of reproducing so many halftones and color-plates would not better have been allotted to the improvement of the maps themselves. There is also an attractive and interesting section on The Races of Mankind, illustrated by the sculptures of Malvina Hoffman; but again the same comment might be made. American publishers of atlases appear to be afraid to make an atlas an atlas. They include half the encyclopedia, and the maps themselves suffer in consequence. The Hammond Atlas is the largest and best atlas produced in the United States, and its quality is a sad commentary on our American standards in this field.

To summarize: a scientist who needs an atlas need not hesitate. The Bartholomew Atlas is immeasurably superior. In fact, only in the far more expensive and oversized German and Italian atlases can one find more. For the price, the Bartholomew atlas is truly outstanding.

BENTLEY GLASS

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30, 1949. Publication 3996.*

The Smithsonian Institution; for sale by the Superintendent of Documents, U. S. Govt. Printing Office, Washington. $2.75. x + 422 pp. + 82 plates, 1 map; text ill. 1950.

Special reprinted articles of biological interest in this volume are: Recent Advances in Virus Research (Wendell M. Stanley); and Time in Evolution (F. E. Zeuner). A number of original articles have also been included: More about Animal Behavior (Ernest P. Walker); The Breeding Habits of the Weaverbirds: a Study in the Biology of Behavior Patterns (Herbert Friedmann); and New Zealand, a Botanist's Paradise (Egbert H. Walker).

SCIENCE NEWS—15, 16, 17.

Edited by J. L. Crammer. Penguin Books, Harmondsworth, Middlesex. Allen Lane, Baltimore. 35 cents ea. (paper). (15) 194 pp. (16) 176 pp. + 16 pl.; text ill. (17) 159 pp. + 16 pl.; text ill. 1950.

Biological articles: Human Colour Vision (H. Hartridge); The Blood of Water Fleas (H. Munro Fox); Blood Groups (G. Fulton Roberts); Some Thoughts on Compound E (H. O. J. Collier); Fuel Consumption in the Flying Insect (V. B. Wigglesworth); Group Dynamics (G. Rattray Taylor); The Chemistry of Paralysis (H. O. J. Collier); The Early History of Man (L. S. B. Leakey); The Instrumentation of the Living Body (J. W. S. Pringle); and various topics such as penicillin and bacteria, animal viruses, dating the past, chemistry and heredity, insect transport, and sensory pits in Research Report, by A. W. Haslett. Many of the articles dealing with the physical and earth sciences will also be of profound interest, in particular Physics and Metaphysics, by Max Born, and My Attitude to Quantum Theory, by Albert Einstein. The authoritative review by Leakey of the recent East African finds, which illuminate the entire story of Pleistocene man and his forebears in the Miocene, deserves special commendation. Number 15 contains a cumulative Index to all numbers of Science News 1–15.

MEDICAL PHOTOGRAPHY—RADIOGRAPHIC AND CLINICAL. *Fourth Edition.*

By T. A. Longmore, with a foreword by Brigadier D. B. McGrigor. Focal Press, London and New York. $15.00. 1008 pp.; ill. 1949.

The 1st edition of this publication (1944) was designed to present the fundamentals of photography and their applications in concise form. This 4th edition has been enlarged to embrace all practical aspects of the subject, while at the same time giving a more detailed treatment of fundamental theory.

Section I, The Phogoraphic Process, devotes 72 pages to the general theory of the photographic process concerned with the production of images of the visible or invisible.

Section II, Photographic Considerations in Radiography, describes x-ray apparatus and devotes 141 pages to the use of this equipment in the production of the radiographic image. The next 69 pages are devoted to the chemistry of development and the processing of the x-ray films. The x-ray darkroom and its equipment are discussed and plans for suggested layouts are included. This section is concluded with a 5-page table that lists causes of defects to be found in unsatisfactory radiographs.

Medical Photography is well covered in Section III, Clinical Photography, and in Section IV, Clinical Phototechnique. The former comprises 132 pages on the principles of the camera, its many types and their uses, illumination, negative materials and the filtering of light.

In Section IV nearly half of its 185 pages are allotted to a discussion on the standardization of camera viewpoint in making progress record photographs of plastic surgery. Considerable space is also given to aids and improvisations toward this end. Other topics included in this section are photography of the eye, the skin, deformities, dental and endoscopic photography, and the technique of photographing gross specimens.

Section V, Reproduction and Processing, discusses the proper choice of material and processing technique necessary for the production of photographs of the highest quality. Methods and equipment used in achieving such results are fully described.

In Section VI, Color Photography, the principles of this medium are presented in about the simplest style possible for this complex subject. The commercially available color films are discussed individually and listed together with the required light sources, filters, and film speed ratings, as determined by several systems popular in the United States and abroad. Color printing processes are summarized, and the various methods are briefly discussed.

Section VII, Special Techniques, contains nearly 100 pages devoted to mass miniature radiography, cineradiography, tomography, seriescopy, kymography, x-ray stereoscopy, stereoscopic photography, simple photomicrography, photomicrography with color transparency materials, macrophotography, electrocardiography, and medical photography with the 16 mm. motion picture camera.

This volume is illustrated with 320 line-cut figures of apparatus, diagrams, and graphs. There are 120 tables and 120 halftone illustrations, 10 of which are in color.

The discussion of the standardization of viewpoint is excellent and the rules laid down therein deserve adoption by hospital photographic departments routinely making plastic surgery record pictures. The many special devices described for carrying out these procedures would occupy considerable space, and it is doubtful that the average hospital photographic studio could accommodate all of them. The medical photographer with an experienced eye could probably dispense with many. Some of the topics, such as gross specimen photography, macrophotography, and photomicrography are only briefly mentioned, and the serious worker in such fields as these will need to seek further information. This book should prove to be an excellent textbook for the beginner in medical photography. The experienced worker will find it a valuable reference work.

CHESTER F. REATHER

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